PROFILE OF AN ACCIDENT FLYING SQUAD

ANALYSIS BY INJURY SEVERITY SCORING SYSTEMS

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Degree of Doctor of Medicine

University of Edinburgh

1988

Declaration of Originality

I declare that the work reported in this thesis was originated and performed by me, with the exception of assistance detailed in the acknowledgements. I also declare that this thesis was composed entirely by myself.

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ABSTRACT

Considerable controversy exists over what constitutes the best approach to the seriously injured or ill patient during the prehospital phase of emergency medical care. One system which has operated in the United Kingdom for the past 30 years is the hospital based Accident Flying Squad. Several workers have reported on their experience in this field of emergency medical care, but although considerable detail has been supplied in relation to call-outs, evaluation has been based on subjective clinical assessment.

The major difficulties encountered in assessing treatment of trauma patients are the multiple injuries which are sustained and the effects of the combination of these injuries. It is essential to define the severity of injury in a quantitative way before any statistically significant statement can be made about the benefits of treatment. The introduction of severity scoring systems in trauma has now provided a basis on which to make objective evaluations. Following a review of existing scoring systems the Injury Severity Score was used in conjunction with a widely accepted statistical model to provide a valid comparison between patients treated by the Edinburgh Flying Squad and a baseline mortality curve.

A study of 459 call-outs during a six year period, 1981-86 was carried out. On analysing 234 trauma patients, comparison of actual mortality with predicted probability of mortality derived from a standard survival curve showed that the lives of six patients were saved by the actions of the Flying Squad. Further analysis defined the group of severely injured patients, Injury Severity Scores 41-55, in whom measures taken at the scene improved survival. There were 133 cases of out-of-hospital cardiac arrest and 11 patients (8.3%) survived to be discharged from hospital.

The effects of a range of resuscitative techniques used at the scene were assessed and in trauma cases related to patients' Injury Severity Scores. The results indicate that in situations involving entrapment with delays in extrication, mass casualty incidents, or in environmental or geographical locations where unavoidable delays will occur before reaching hospital, the hospital based Accident Flying Squad fulfills a useful role.

The analysis suggests that Accident Flying Squads do save lives but the number is small. Nevertheless, the Edinburgh Flying Squad would appear to have amply repaid both the initial outlay and subsequent running costs.

ACKNOWLEDGEMENTS

The work which forms the basis for this thesis was carried out while I was a member of the Accident Flying Squad based at the Royal Infirmary, Edinburgh, between 1981-86.

I acknowledge with gratitude, the boundless advice and encouragement received from Dr. Keith Little and Dr. Colin Robertson who both taught me the essential techniques used in out-of-hospital resuscitation.

I am indebted to my colleagues - doctors, nurses and members of the emergency services - for their support "at the scene" and without whom the squad could not have functioned so efficiently.

My thanks are due to Mr. J. Douglas-Allen, Regional Procurator Fiscal for his help in providing post-mortem reports.

I acknowledge statistical advice from Dr. Dennis Heath, MRC Trauma Unit, University of Manchester.

The illustrations were prepared with the assistance of the Medical Photography Department, University of Edinburgh.

I would like to thank both my parents for their endless support during my medical career.

And last, but not least I acknowledge the forbearance of my wife, Jane.

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List of Abbreviations used in the Text

AIS	Abbreviated Injury Scale
ISS	Injury Severity Score
ICD	International Classification of Disease
OAIS	Overall Abbreviated Injury Scale
PODS	Prediction of Death Score
MISS	Modified Injury Severity Score
PHI	Pre-hospital Index
CNS	Central nervous system
°F	degrees Farenheit
UHF	ultra high frequency
MAST	medical anti-shock trousers
mm	millimetres
Hg	Mercury
%	per cent
N_2O	Nitrous oxide
e.g.	for example
$<$	less than
$>$	greater than
km	kilometres
chi^2	chi-square
SD	standard deviation
hr	hours
df	degrees of freedom
mls	millilitres
fig	figure
p	probability

List of Abbreviations used in the Text, continued

CPR	cardiopulmonary resuscitation
LD	lethal dose
DOA	dead on arrival
ALS	advanced life support
IM	intramuscular
IV	intravenous
ET	endotracheal
G	guage
cm	centimetres
mg	milligrams
g	grams
"	inches

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CHAPTER 1

INTRODUCTION

> "With my flying ambulance I followed the movements of the guards till the decisive moment, and we dressed the wounded on the ground".
>
> Dominique Jean Larrey
> 1766-1842

1.1 Origins of Accident Flying Squads

The concept of "first aid to the wounded" is not new. Napoleon's surgeon-in-chief, Baron Dominique Jean Larrey appreciated the requirement for rapid evacuation and early medical care when he set up the celebrated "flying ambulances" in the first half of the 19th Century (Dible, 1970). There was however a lamentable delay in developing those principles which Larrey had established and it was only in the latter part of the 1939-45 war that modern techniques of resuscitation came to be applied to wounded personnel at, or close to, the locus of injury (Trueta, 1944). Subsequently, during the military conflicts in Korea, Vietnam, the Middle East and more recently in the Falklands, specially trained "paramedic" soldiers, together with rapid evacuation using helicopters, transformed the fate of the seriously injured soldier (Eisman, 1967; McNabey, 1981; Jackson et al., 1983; Williams et al., 1983). However, the application of lessons learnt during war time to civilian experience is often delayed. Nowhere is this more powerfully exemplified than in the establishment of hospital based Accident Flying Squads.

An early civilian scheme developed by Gissane for providing skilled medical aid at the scene of the severely injured, operated from the Birmingham Accident Hospital in the form of a large mobile surgical unit (London, 1982). Experience showed that the severity of the incident was often greatly exaggerated or that the patient(s) had already been removed by ordinary ambulance, which were faster and less cumbersome. An unpublished survey of 100 consecutive call-outs showed that in only 4 cases might it have offered important advantages over an ordinary ambulance and consequently Gissane's idea was eventually abandoned in 1953. A similar mobile operating theatre was introduced in 1957 by Professor Gögler (1965) in Heidelberg, West Germany. This scheme met with the same problems and the "bus" was superceded by a mobile surgical car in 1964. Snook (1972a) reported an alternative hospital based scheme resulting from his experience of personal attendance as accident medical officer to Bath Fire and Ambulance Service. However a single-handed service of this type had obvious limitations.

In 1955, the first Accident Flying Squad was developed

by Collins (1966) at the Accident and Emergency Department, Derby Royal Infirmary and similar schemes soon followed (Hall, 1965). These squads provided a fully equipped medical and nursing team with rapid transport to the scene of the accident. Reports from Germany (Echtermeyer & Kalbe, 1985a,b), France (Drouet, 1982a,b), Russia (Hindle et al., 1975) and Israel (Silverston, 1980a) also describe schemes based on the hospital based Flying Squad principle. In the early 1970s, several other centres within the United Kingdom began to appreciate the potential value of such squads and the number of schemes has since increased rapidly.
A survey performed in 1981 indicated that there were 47 centres with this facility (Bodiwala, 1982).

1.2 The prehospital "gap" in medical care

Trauma is the commonest cause of death in the United Kingdom between the ages of 1 and 34 years (Office of Population Census and Surveys, 1986). In 1985 the number of deaths in the United Kingdom from accidental causes was 14,399 (Central Statistics Office, 1987a).
Of these, 5,583 deaths were due to road accidents and the incidence of road users killed or seriously injured in the same year was 138.3 per 100,000 of the population. The average cost of a fatal road accident in this country is estimated by the Department

of Transport to be £200 thousand and that of all road accidents amounts to £2.8 billion per annum. The number of non-transport accidents resulting in death in 1985 was 8,575, including 5,729 home accidents. Reported fatal and major injuries occurring in the construction and manufacturing industry have increased since 1981, and in 1985 was 13,141 for all works activities (Central Statistics Office, 1987b).

In 1971, the Board of Science and Education reported on an enquiry into gaps in medical care in the United Kingdom. They were particularly critical of the lack of medical attention at the site of accidents and during the subsequent transfer to hospital and made recommendations to the Government for the correction of such a deficiency. Hospital based Accident Flying Squads have been recommended as one means of filling such a gap (Little, 1971).

It has been claimed that 43% of motorcyclists and vehicle occupants who die as a result of road traffic accidents may have had a greater chance of survival had medical treatment been available at the scene within 10 minutes of the injury (Mackay, 1969). This figure was based on technical rather than the practical possibilities of recovery and has been regarded as somewhat optimistic (Macdonald et al., 1981). Easton (1977) has described a "therapeutic vacuum" during the first 20 minutes after injury and has suggested that between 3% and 20% of deaths might have been prevented with proper resuscitative measures.

The two major preventable causes of death following trauma are respiratory obstruction and/or inadequate ventilation and hypovolaemia. Several attempts have been made to quantify these components. Lauppie (1954) indicated that 14% of patients who died within two days of their injury did so because of respiratory obstruction. A post-mortem study of 374 victims of road traffic accidents suggested the incidence to be 5% (Ruffell Smith, 1970). In a major prospective study of 2,392 trauma patients admitted to 12 hospitals reported by Hoffman (1976), airway obstruction was found by Casualty Officers in 10.7% of patients who died and in only 0.7% of survivors. In his series, inhalation of blood or vomitus was present in 36% of all deaths related to road traffic accidents. He considered that inhalation was the cause of death in 2% and contributory in 8%. In a further study, Hoffman (1983) reported that 39% of patients who subsequently died were found to have had an obstructed airway when first seen by ambulancemen at the scene of the accident. Frey et al. (1969), attributed the cause of death to obstruction of the airway in 13 of 74 patients at the site of the accident. In a retrospective study over a 5 year period, Yates (1977) concluded that patients who died in hospital as a consequence of trauma and in whom airway obstruction had been present, had less severe injuries as measured by a standard scoring system than those in whom no such obstruction could be found. This therefore strongly implied that airway obstruction in such a context contributed to mortality. After studying 144 deaths from road traffic accidents occurring prior to arrival in hospital, Gilroy (1985) concluded that in 7 cases there may have been a contribution to death from aspiration of blood or vomit. He also stated that in 2 further cases with chest injury, early provision of medical care may have been of benefit. Comparable studies by Spelman et al. (1970) and Gögler (1972) have shown similar figures for the United States and West Germany respectively.

The situation with regard to blood loss is less well documented. Hoffman's (1976) study showed that for patients who died with associated blood loss, 59% died instantly while 85% died within 6 hours, suggesting that perhaps 25% of deaths from hypovolaemia could potentially have been prevented. Sherriff (1981) has suggested that one third of patients who died from road traffic accidents did so because of blood loss and 7-10% of these could have been saved by adequate infusion.

Although these studies have been criticised on the grounds of irreproducability and subjectivity, it would nevertheless appear that there is a sizeable proportion of patients whose deaths could have been prevented had medical aid been immediately available.

1.3 Rationale for Prehospital trauma care

If the approach to the delivery of prehospital medical care is to be addressed in a rational way there must be an understanding of the pathophysiology and epidemiology of trauma. Data from several institutions in the United States has shown that death from trauma has a trimodal distribution (Fig. 1) (Baker et al., 1980; Lowe et al., 1983). These deaths have been further categorised into immediate, early and late (Trunkey, 1983). "Immediate deaths" describes the first peak of death within seconds or minutes of injury. Invariably these deaths are due to lacerations of the brain, brain stem, upper spinal cord, heart, aorta or other large vessels. Although few of these patients can be saved, some deaths have been prevented in large urban areas in the United States with rapid transport facility (Harnar et al., 1981). Over 50% of all trauma deaths fall into the "immediate category" and the only possible way of effectively reducing mortality in this group is via preventive measures e.g. seatbelts and random alcohol breath testing (Trunkey, 1983).

"Late deaths" occuring days or weeks after the injury account for approximately 20% of all trauma deaths. In nearly 80% of these cases, the cause of death is sepsis and multiple organ failure.

The focus of attention in relation to the development of Accident Flying Squads relates to the second (early) death peak. These deaths occur within the first two to three hours after injury. Approximately 30% of all trauma deaths fall into this category. Three types of injury account for virtually all prehospital deaths: direct cerebral and high spinal cord injury causes approximately 50-55% of deaths; exsanguination due to thoracic, abdominal and major vascular injuries, or severe pelvic or long bone fractures accounts for 30-40%; airway obstruction, open or tension pneumothorax and hypoxia from other causes accounts for 10-15% of the total (Trunkey, 1985).

The Field report (1976) revealed that 60% of deaths from head injury occurred before admission to hospital; 40% were dead at the scene of the accident and 20% at hospital prior to admission. This raised the question of whether better care at the site of the accident and during transport to hospital might save lives. A high incidence of preventable factors contributing to death in patients with potentially salvageable head injuries has been reported (Rose et al., 1977; Jeffreys & Jones,

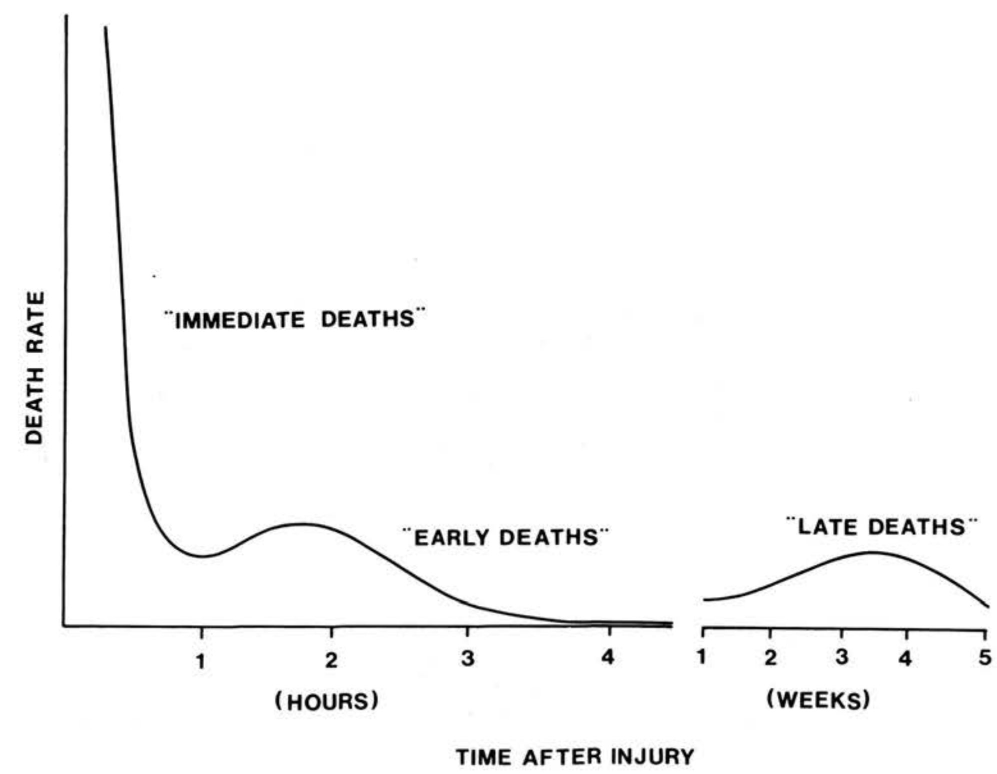

Figure 1 - Trimodal distribution of death following trauma

Reproduced from Trunkey (1983)

1981). Such avoidable factors include delay before evacuation of intracranial haematomas (Mendelow et al., 1979), secondary brain damage produced by hypoxia and hypotension (Price & Murray, 1972; Miller et al., 1978; Kohi et al., 1984) and uncontrolled convulsions (Jennett & Carlin, 1978). Patients with massive head injuries which result in apnoea or early brain stem herniation are not salvageable. Those who are salvageable usually do not develop extreme elevation of intracranial pressure for at least 30-60 minutes (Trunkey, 1985). Preventable death in the field is therefore usually due to the airway problems which occur with unconsciousness, rather than the head injury directly. Definitive airway protection at the scene provides secondary benefit in facilitating hyperventilation to reduce cerebral oedema. The neurological lesions cannot be treated in the field and are best handled by rapid transport to prompt and definitive neurosurgical care (Seelig et al., 1981). Spinal protection, particularly of the cervical spine, is also an essential manoeuvre which can be quickly accomplished (Podolsky et al., 1983).

The second most common cause of death in the early or immediate category is exsanguination. For isolated sources of external bleeding, direct pressure is usually appropriate. However, the majority of patients who exsanguinate do so from internal bleeding which is not controllable without surgical intervention. The only treatments which are potentially beneficial are the establishment of intravenous access and rapid fluid administration or the use of the pneumatic anti-shock garment - both of these intervensions are controversial.

The volume of infusion given to 52 consecutively injured patients was reviewed by Smith and co-workers (1985) who found that the time required to establish intravenous access in the field consistently exceeded the travel time to hospital, while the volume infused was inadequate. Similarly, McSwain et al. (1980) reported 100 cases in which the time to start an intravenous infusion averaged 11 minutes. Since surgical cases usually have severe hypovolaemia of nearly 50% of the circulatory volume (Holcroft & Bodai, 1987), it seems unlikely that severe blood loss can be replaced by infusion before reaching hospital, particularly in an urban and suburban setting (Bodai et al., 1987). Carveth and colleagues (1974) have affirmed that fluid resuscitation may not compensate for the delay necessary to establish an intravenous line, particularly in those settings when transport times of less than 10-15 minutes are possible. Anderson et al. (1987) have reported an early emergency care study on the potential and benefits of advanced prehospital care in the United Kingdom. In their estimation of 32 cases of hypovolaemia, none would have had their long term survival improved by the use of advanced techniques, although one patient with associated coma might have been resuscitated by a pneumatic anti-shock garment. This view has however been challenged by Baskett & Sleet (1987). Although prehospital intravenous fluid replacement remains controversial, when a time delay occurs for example in protracted extrication, the value of such treatment is not contested (Trunkey, 1984).

1.4 "Accident" Flying Squads for medical emergencies

Although the original emphasis of hospital based Accident Flying Squads was upon industrial and road traffic accidents, the service now embraces a whole range of emergencies. Medical emergencies now represent a significant proportion of the workload of "Accident" Flying Squads. Rowley & Collins (1979) reported a steady increase in demand for such emergencies; medical cases accounting for one fifth of their call-outs. Of these, over 50% were due to out-of-hospital cardiac arrests. In a retrospective review of calls made by the Accident Flying Squad at Leicester Royal Infirmary between 1978 and 1981, "contrary to expectation", the squad attended a larger number of patients who had not suffered accidents (Harrop & Bodiwala, 1983). In their study, cardiac arrests accounted for 56% of medical calls. Coals

(1988), reporting on the Chester Flying Squad documented an eight fold increase in calls to non-traumatic emergencies between periods 1976-77 and 1985-86 inclusive.

Pantridge & Geddes (1967) were the first to describe an emergency system to resuscitate pre-hospital cardiac arrest patients. They demonstrated that the correction of ventricular fibrillation was a practical proposition. Similar schemes have proved successful both in the United Kingdom (Briggs et al., 1976; Mackintosh et al., 1978; Jones, 1983; Adgey, 1984) and in the United States (Sherman, 1979; Eisenberg et al., 1982, 1984). Studies have shown that discharge rates for out-of-hospital ventricular fibrillation may be up to 30% (Schaffer & Cobb, 1975). The most important predictors of survival from pre-hospital cardiac arrest are the time from collapse to basic CPR and the time from collapse to advanced life support (Eisenberg et al., 1980a). The concept of starting cardiopulmonary resuscitation soon and stopping it quickly has been referred to as a "therapeutic window" (Abramson et al., 1984). Emphasis has been placed on the need to institute basic life support within 4 minutes and the need to provide advanced emergency care within 15 minutes (Cummins & Eisenberg, 1985a). The best results in cardiopulmonary resuscitation out-of-hospital have occurred when lay bystanders have initiated basic life support and continued until advanced life support is available (Cobb et al., 1980; Cummins et al., 1985; Cummins & Eisenberg, 1985b). Results in the United Kingdom have shown that despite improving pre-hospital care, results may be disappointing if it is not paralleled by an increase in bystander initiated cardio-pulmonary resuscitation (Hampton et al., 1977; Hampton & Nicholas, 1978). A number of workers have advised against the introduction of advanced skills unless there is frequent citizen cardiopulmonary resuscitation and short response times (Eisenberg et al., 1979a, b; Cobb & Hallstrom, 1982; Vincent et al., 1984). The results from centres which operate hospital based Flying Squads responding to out-of-hospital cardiac arrest calls have previously been criticised because of the delay in mobilising the team (Robertson & Steedman, 1985).

1.5 Evaluation of Accident Flying Squads

Blanket statements that flying squads "undoubtedly save lives" remain open to question (Spencer, 1985). In Collins' (1966) original paper, the conclusion that "the success of early treatment of the injured by the Flying Squad has amply justified the efforts of the team" was not supported by objective data. Snook (1972a, b) judged that attendance by his Flying Squad at an accident scene was of direct value for 1 in 3.5 calls.

He outlined a group of patients whose deaths had been "probably possible" to prevent. He stated that of 302 casualties, immediate medical care was responsible for the survival of 6 patients and contributed to the survival of a further 4 patients i.e., it saved the lives of 3% of patients. His justification for this analysis was entirely subjective although considerable detail regarding each of the cases was given. Little (1976) analysed data from 403 patients treated by the Derby Flying Squad between 1967 and 1972. He pointed out that "there are few patients whom one can categorically prove had their lives saved by the Flying Squad but there are many whom on clinical judgement should not have survived but did". He divided patients into 3 categories of possible benefit. His categories of 3A and 3B were those patients whose lives were possibly or definitely saved as a result of intervention by the Flying Squad. His overall conclusion was that 48% of patients materially benefited from treatment at the scene and that 17.5% had their lives prolonged or saved. Little (1981a), commenting on the study pointed out that there were no injury severity scoring systems available at that time and admitted that objective evaluation of immediate care was extremely difficult, conclusions therefore being based on clinical evaluation. Adams (1982) has presented evidence "for" immediate care including that of Accident Flying Squads and used Dooley's (1978) care index for the analysis;

the care index is derived from a ratio of immediate to subsequent mortality with and without medical assistance. She claimed that approximately 20% of road traffic accident deaths could have been prevented by the provision of immediate medical care.

The first objective evaluation of a flying squad scheme was performed in Chester (Gorman & Coals, 1983). Of the 152 patients treated by the squad between 1974 and 1981, 110.1 patients were predicted to survive and 110 actually did survive. However, they claimed that on clinical grounds measures taken at the scene unequivocally led to the survival of 6% of those alive at the scene.

The claims that Accident Flying Squads contribute to the management of critically ill patients whose condition could be expected to deteriorate before or during transfer to hospital has to date been based on empirical and emotional appeal rather than on scientific evidence of their value. There has as a result been a plea for objective evaluation to confirm the many subjective judgements of benefit (Anonymous, 1979).

The main difficulties encountered in assessing treatment of trauma patients are the multiple injuries which are sustained and the combined effects of these injuries.
It is essential to define the severity of injury in a

quantitative way before any statistically significant statements can be made about the benefits of treatment (Baker et al., 1974). The introduction of severity scoring systems has now permitted such an objective analysis of trauma care to be made.

The research work which forms the basis of this thesis involves the application of an Injury Severity Scoring System to objectively evaluate the treatment provided by a hospital based Accident Flying Squad. The trauma scoring systems which are currently available are reviewed and the equipment used by the squad and its organisation are discussed.

CHAPTER 2

SEVERITY SCORING IN TRAUMA

> A gaping wound of the head down to but not penetrating the skull: "this ailment I will treat".
>
> A similar wound with skull fracture and bleeding from the nose and ears with stiffness of the neck: "an ailment with which I will content".
>
> Another similar case but with bone fragments driven in deeply: "an ailment not to be treated".
>
> The Smith Papyrus
> circa 1700 BC

2.1 Indices of Severity

2.1.1 Introduction

Classification of the severity of injury is fundamental to evaluation of patient care in trauma and estimates of the severity of injury appear in the earliest known surgical text, the Smith Papyrus (Breasted, 1930). However, the major problem encountered in the evaluation of such care arises from the nature of the injuries sustained and from their combined effects; thus difficulties arise in the analysis of comparable groups of patients treated by different means. Quantitative measures of injury severity of proven reliability and validity are therefore essential to permit appropriate resource allocation, the prediction of outcome and the assessment of emergency medical care.

2.1.2 Early classification systems

During World War II, a system was devised which depended on an assessment of blood loss estimated in pints and of the amount of injured tissue measured in fistfuls, together with measurement of blood pressure and pulse rate (Grant, 1941). This system was successfully used on battle casualties (Green et al., 1949) but was crude, lacked a numerical scale and was difficult to apply to closed injuries. The first widely recognised severity scale was developed by DeHaven (1952) to study light aircraft accidents. This five point scale based on risk to life was subsequently adapted by the Cornell Injuries Research Group in the United States (Ryan & Garret, 1968) to investigate road traffic accidents and similarly applied in the United Kingdom (Mackay, 1966). Although these systems provided a simple and effective means of rating injuries employing the terms moderate, serious, critical and fatal along with corresponding code numbers, they were still regarded as inadequate.
The advent of multi-disciplinary accident investigation teams led to the development of a number of other scales by universities (States, 1969), independent researchers (Williams & Schamadan, 1969) and safety organisations

(Campbell, 1966), but were often not comparable and each had limitations. These drawbacks have led to an increasing interest over the past 20 years in the development of numerical scales that measure severity of illness or injury.

2.1.3 Concept of numerical severity indices

Scales of severity share the common goal of describing injury through the use of quantitative measures. Severity indices are defined as numerical ratings attached to selected patient charactistics which provide a reliable and valid means of assessing the probability of a given outcome measure (Gibson, 1981). Thus if the injury status of an individual patient is represented by a number of parameters, x1, x2, ... xn, the severity index is a function that combines the n parameters into a single value (Krischer, 1976). The majority of indices utilise a summation approach to derive a severity value.

Severity indices vary according to the criteria on which severity is measured (e.g. threat to life, residual disability), the parameters used (physiological, anatomical or biochemical), their locus of application (e.g. pre-hospital, resuscitation room, intensive care) and the methods used to derive the numerical scale, i.e. whether ratings are derived by a concensus of experts or from experimental data generated from a variety of emergency care systems (Krischer, 1979).

2.1.4 Evaluation of severity indices

Injury severity indices as with any other measure of an underlying variable must meet certain criteria in order to establish their usefulness as clinical or research tools (McKenzie, 1984). Three standards have been recommended on which to base such an evaluation.

(1) the index must be valid and should demonstrate a high correlation with a particular outcome measure.

(2) the index should be reliable, so that the same rater at other times, or different raters at the same time will derive an identical score.

(3) the data required for a particular index should be readily available at the locus at which it is to be applied (Gibson, 1981). If an index is to be used in pre-hospital emergency care assessment, the index should primarily reflect the mortality resulting from the initial insult to the body and not the variable nature of subsequent clinical intervention.

2.1.5 Scope of injury severity indices

Indices of severity are essential for allocating, describing and evaluating emergency medical care. They facilitate the process of triage in the pre-hospital setting, in the Accident and Emergency department and in major disaster situations. They are useful aids in determining which patients should be treated first, whether a patient should be transferred to a specialist unit and for pre-hospital decisions as to the preferred category of receiving hospital. They are of increasing importance in describing the nature of injuries resulting from such environmental hazards as road traffic accidents as well as assessing trends and the impact of interventions aimed at reducing either morbidity or mortality. However the most important current function of severity indices is in evaluating and comparing the quality and outcome of emergency medical care between two or more facilities or systems or between points in time. Because the outcome from emergency care is a joint function of the severity of the patient's illness or injury and the quality of patient care, it is impossible to compare the survival within two emergency medical care systems without measuring and allowing for differences between patients' severity of injury.

2.2 The Abbreviated Injury Scale

2.2.1 Introduction

Many of the scales developed by the multidisciplinary accident investigation teams of the 1950s had serious shortcomings from the medical standpoint. There was therefore a critical need for a uniform scale that would be acceptable to both physicians and others involved in morbidity and mortality audit, which would lead to a consistent method of accumulating information and facilitate comparison of data from different sources.
In an attempt to establish a uniform rating system and standardise the language used in describing injuries, the first Abbreviated Injury Scale (AIS) was published under the auspices of the Joint Committee on Injury Scaling (1971), comprised of representatives of the American Medical Association, the American Association for Automotive Medicine and the Society of Automotive Engineers.

2.2.2 Development of the Abbreviated Injury Scale

After a thorough review of existing scaling and classification systems, a group of physicians, engineers and researchers concerned with Road Traffic Accident investigation devised an elementary scale (following a three day workshop) that was acceptable to all disciplines. Although based largely on subjective clinical assessment and coding for less than 75 injuries, the AIS had been initially introduced to gain field experience and as a basis for future refinement. The AIS in this original form was a scale that mixed severity and outcome. The lower codes (1-5) were assigned on the basis of injury severity alone whereas fatal codes (numbered 6 through to 9) were used when death occurred within 24 hours of injury irrespective of injury severity. As a result, different AIS ratings (depending on whether or when death occurred) could be assigned to similar injuries and meaningful mortality rates could not be calculated. Following interim versions in 1974 and 1975 the AIS was published in dictionary format in 1976 (Joint Committee on Injury Scaling). The "fatal" codes had been eliminated and included a new code AIS-6 to be applied to specific injuries "that invariably result in death given our present emergency care capabilities". Over the last decade, the AIS has evolved and been refined and is now the system of choice for assessing impact injury severity. Numerous additions and clarifications have been implemented and the most recent revision, AIS-85, contains more than 1,200 separate injury descriptions.

2.2.3 The AIS Dictionary

"Abbreviated" refers to the assignment of a single code number on a scale 1 to 6 for specific injury descriptions:-

AIS	Severity
1	Minor
2	Moderate
3	Serious
4	Severe
5	Critical
6	Maximum Injury

The AIS dictionary is divided into sections as follows; Head and Face, Neck, Thorax, Abdomen and Pelvic contents, Spine, Extremities and bony pelvis. A section entitled External deals with injury to the integument including burns.

The AIS is an injury rating system and not a system for coding fatality. Injuries are assigned AIS codes without regard to whether or not the victim dies. AIS-6 is reserved for those injuries that are unsurvivable with current techniques. In order to be coded AIS-6, specific knowledge of the severity of the injury must be available, not merely knowledge that the death occurred (Petrucelli et al., 1981).

The AIS clearly distinguishes between an injury which is coded and the outcome of an injury which is not coded but it can be used to qualify the injury. For example, in the chest, haemothorax is not an injury per se but may result from fractured ribs. It is the fracture that is coded, although it is acknowledged by upgrading the AIS code by 1, that the presence of haemothorax adds to the severity of rib injury. An exception to this general philosophy occurs when coding diffuse brain injury because clinical signs and symptoms are the only means of measuring the severity of such injury.

Although the AIS was primarily introduced for coding injuries sustained following blunt trauma, the latest revision AIS-85, incorporates a limited number of descriptions for penetrating injury.

2.2.4 Limitations of the AIS

It is important to recognise that the Abbreviated Injury Scale is not a linear progression. The difference between AIS 1 and AIS 2 may not necessarily be the same as that between AIS 4 and AIS 5. The AIS 1-6 numerical code is simply a means of distinguishing between the categories of injuries within a similar range of severity. Even within the same code the injuries may not be strictly comparable (Petrucelli et al., 1981).

The AIS therefore has limitations when applied to patients with multiple injury as it is not possible for example, to derive an arithmetic mean value (Bull, 1978). Various weightings have therefore been proposed to take into account of these inequalities.

2.2.5. AIS to assess multiple injuries

An Overall AIS (OAIS), based on the clinical judgement of the coder (but not the sum or the mean) has been recommended for assessing the multiply injured patient but is unreliable for research purposes (Joint Committee on Injury Scaling, 1980). The Maximum AIS (MAIS) is the highest single code in a victim with multiple injuries and although it has been shown to correlate with mortality, the relationship is disproportionate, confirming that the scale is non-linear (Baker et al., 1974). The Pobability of Death Score (PODS) requires the calculation of weighting factors for the two highest AIS codes as well as for the victims age and although the author claims that the score is statistically superior to others, it has not met with widespread acceptance (Sommers, 1981). The most widely used system for measuring the cumulative effects of injury is the Injury Severity Score devised by Baker et al. (1974) and is based on the AIS.

2.3 The Injury Severity Score

2.3.1 Introduction

It is essential to take into account differences in severity when comparing the morbidity and mortality of various groups of patients during evaluation of their emergency care (Baker, 1971). Two research approaches can be used to overcome this difficulty. The first is to compare only patients with similar injuries. However the number of injuries of a specific type and severity are often too small to support statistically sound conclusions. The second approach is to compare patients whose injuries, although not necessarily the same anatomically, are of the same severity. In 1974, Baker and co-workers used the AIS to classify patients into groups on the basis of severity of injury and determined the extent to which AIS correlated with mortality. This analysis led to the development of the Injury Severity Score, representing a numerical description of the overall severity of injury (Baker et al., 1974; Baker & O'Neill, 1976).

2.3.2 Development of the Injury Severity Score

The ISS was based on an analysis of 2,128 road accident victims admitted to eight Baltimore hospitals over a 2 year period. Information was obtained from hospital records and post-mortem reports and AIS ratings derived for the injuries of each patient. The AIS scoring was modified for the purposes of the study in two respects. Firstly, all fatalities were coded with a "blinded outcome". Thus all injuries were rated by severity and the most severe injury severity code was 5. Secondly, facial injury, common in road traffic accidents, was separated from cranial and neck injuries. For the purposes of scoring the body was divided into six regions:

Head or neck
Face
Chest
Abdominal or pelvic contents
Extremities or pelvic girdle
External integument

Head or neck injuries include injury to the brain or cervical spinal cord, fractures of the skull or cervial spine and injury to the ears. Facial injuries include those involving the mouth, eyes, nose and facial bones. Chest injuries and injuries to the abdominal or pelvic contents include all lesions to internal organs in the respective cavities. Chest injuries also include those to the diaphragm, rib cage and thoracic spine. Lumbar spine lesions are included in the abdominal and pelvic area. Injuries to the extremities, the pelvic and shoulder girdle include sprains, fractures, dislocations and amputations. External injuries include lacerations, contusions, abrasions and burns, independent of their location on the body surface. After grading, each body area was categorised by the highest AIS in that area.

Mortality was found to increase disproportionately with the AIS rating of the severest injury: AIS 1 - 0%, AIS 2 - 0.5%, AIS 3 - 3%, AIS 4 - 16%, AIS 5 - 64%. In addition death rates varied within each AIS grade for the severest injury according to the AIS grade of the second most severely injured area. These results confirm the non-linearity of the AIS and clearly, for the patient with multiple injuries, it would be inappropriate to summate scores or derive a mean value. The simplest non-linear relationship is quadratic and this led Baker and her colleagues to investigate the possibility of squaring the highest AIS within each body area before adding them together. When the AIS grades for each of the two most severely injured areas were squared and then added together, it was found that death rates were similar for comparable totals. For instance, patients whose two most severely injured areas were 5 and 0 and for those graded 4 and 3 (sum of the squares = 25 in both cases), death rates were 22% and 24% respectively. When the AIS grades for each of the three most severely injured areas were squared and the results summated, comparable totals again proved to be associated with similar mortality rates and the correlation between total injury severity and mortality was further improved. Including the grade of the fourth most severely injured area had no additional effect. The Injury Severity Score was therefore defined as the sum of the squares of the highest AIS grade in each of the three most severely injured areas. The maximum score for any body region is therefore 25 (5^2) and the maximum ISS is thus 75. Any patient with an injury severe enough to attract an AIS code of 6 is automatically awarded an ISS of 75. A fatality is not in itself sufficient to attract an AIS of 6, the severity of the injury must be known.

The ISS is discontinuous as it is based on a sum of three squares of numbers 0-5. There are 44 stages between the scores 1 and 75 and the gaps become more frequent as the score of 75 is approached (Stoner et al., 1977). However, Bull (1975) found that this feature of the scale could be ignored when studying the relation between mortality and severity.

2.3.3 Age weighting

Older patients are more likely to die from less severe injuries than younger patients. Baker et al. (1974)

found that an ISS of 41, 32 and 26 were associated with a 50% mortality in the respective age groups 0-49 years, 50-69 years and 70+ years. Bull (1975) used Probit analysis (Finney, 1947) to linearise the mortality data in separate age groups in relation to 1,333 road traffic accident patients admitted to the Birmingham Accident Unit and used the ISS to establish 50 per cent "lethal doses" of injury (LD 50 values) for patients of a given age. He found that an ISS of 39.7 ± 2.9 (mean ± SD), 29.4 ± 2.5 and 20.2 ± 1.6 were associated with 50% mortality in the respective age groups 15-44 years, 45-64 years and 65+ years. There were insufficient cases in the 0-14 age group for Probit analysis. Stoner et al., (1977) affirmed that in mortality studies ISS must be weighted for age and Yates (1977) modified Bull's Probit lines (fig. 2) producing age weighting by correcting the ISS value of patients to that appropriate to the 45-64 age group. For example, a patient aged 70 with an ISS of 30, has an age corrected score of 40.

Bull (1978) also derived a grid of expected mortality for different combinations of ISS and age groups above 15 years based on his initial data (fig. 3); patients were divided into decades and ISS into equal groups 0-4, 5-9, 10-14 etc. An approximate probability of mortality was obtained for each age group and ISS. For example, a patient aged 25-34 with an ISS of 40-44, would have an approximate probability of mortality of

0.7.

2.3.4 ISS to predict outcome

Although some injuries are invariably fatal and are presently classified on the AIS system as 6, attempts to give a prognosis for individual patients using the ISS are unlikely to be successful. With less severe injury, the potential for alternative outcome changes with the course of the patient. At any given stage the risk of death can be estimated from the proportion of patients with the same severity of injury who eventually die. However, outcome is influenced both by a patient's response to injury and the efficiency of treatment. These inherited and acquired differences are beyond the scope of the ISS system. Therefore when scoring systems are used to give a prognosis it must be in terms of probabilities. This gives sufficient information for the assessment of groups of patients and it is justifiable to calculate the "expected" number of deaths and compare it with the "observed" number within each group (Bull, 1983). Yates (1977) included a predicted chance of survival in his modification of Bull's Probit lines which can be utilised to predict overall survival for a group of patients.

2.3.5 Utility of the ISS

The ISS has been shown to correlate closely with mortality resulting from road traffic accidents (Bull, 1975; Gerritson et al., 1983) and other types of blunt trauma (Semmlow & Cone, 1976; Goris & Draaisma, 1982). While the ISS is well validated for blunt trauma it does not appear to accurately reflect the severity of injury when applied to penetrating trauma (Stoner et al., 1977) and the correlation with mortality is poor in gunshot wounds (Beverland & Rutherford, 1984). In addition to mortality the ISS has been validated for other outcome measures; including survival time (Baker et al., 1974), disability (Bull, 1975), financial consequences (Slocum & Vila, 1980), and a number of metabolic responses including plasma lactate (Stoner et al., 1980), cortisol (Stoner et al., 1979) and catecholamines (Little et al., 1985).

McKenzie and co-workers (1985) have demonstrated that the level of inter and intra-rater reliability is high, although clinicians are more accurate at scoring the ISS compared to non-medical staff, and reliability is somewhat higher for blunt versus penetrating injury.

2.3.6 Source of information

The reliability and validity of any injury severity scale ultimately depends on the accessibility and quality of the information upon which the index is based. Various types of information are usually available to score the severity of injury; Accident and Emergency records, in-patient notes, ICD-coded discharge diagnoses and post-mortem reports. Analysis of field experience has indicated that in-patient notes are more reliable than Accident and Emergency sheets and that more injuries can be identified (McKenzie et al, 1985). Consequently the Joint Committee on Injury Scaling (1980) strongly recommend that the investigator uses in-patient notes as the primary source of information for coding purposes. Conversion tables are available, allowing AIS coding from International Classification of Disease Codes provided in hospital discharge summaries (Semmlow & Cone, 1976) and several single page charts have been devised which facilitate and enhance the prescision of AIS coding (Barancik & Chatterjee, 1981; Greenspan et al., 1985).

2.4 Alternative Anatomical Severity Indices

2.4.1 International Classification of Disease Coding

A major drawback of the Injury Severity Score and the Abbreviated Injury Scale on which it is based, is the need to review the entire medical record for adequate scoring.

A more accessible method would be to use a system based on the International Classification of Disease (ICD) anatomical diagnosis which may be employed in the patient's discharge summary.

To determine whether ICD coded discharge diagnoses could be used to rate injury severity based on the AIS, the compatibility of the two injury classification systems was examined by Garthe (1982). He found that 67% of the ICD codes could be assigned AIS codes. Reasons for the non-compatability included lack of qualifying information for ICD codes that combine injuries of different severity and different definitions between the ICD and AIS.

Because of these limitations it has been recommended that conversions based on the current versions of the ICD and AIS be used only for statistical analysis of trends and not assessment of patient severity (McKenzie

& Garthe, 1983).

2.4.2 The Anatomic Index

The Maryland trauma team derived the Anatomic Index based on the statistical analysis of observed mortality and gave mortality probabilities for different ICD categories (Champion et al., 1980a). Unfortunately the ICD is primarily an anatomical listing and many degrees of severity can be included in one category (Bull, 1983). This is particularly evident for example in head injury, when the ICD only separates cerebral contusion into open and closed. Although modifications were made by the team, instituting their own extended subdivisions, these would have to be generally accepted if the method were to be more widely used.

2.4.3 The Revised Estimated Survival Probability Index (RESP)

The RESP is an index of survival rates associated with ICD injury codes (Levy et al., 1978a, b & 1982). The original index failed to take into account the age effect on survival (Krischer, 1978) and was therefore revised. For a patient with multiple injuries, the index is derived by multiplying the probability of survival associated with each individual injury.

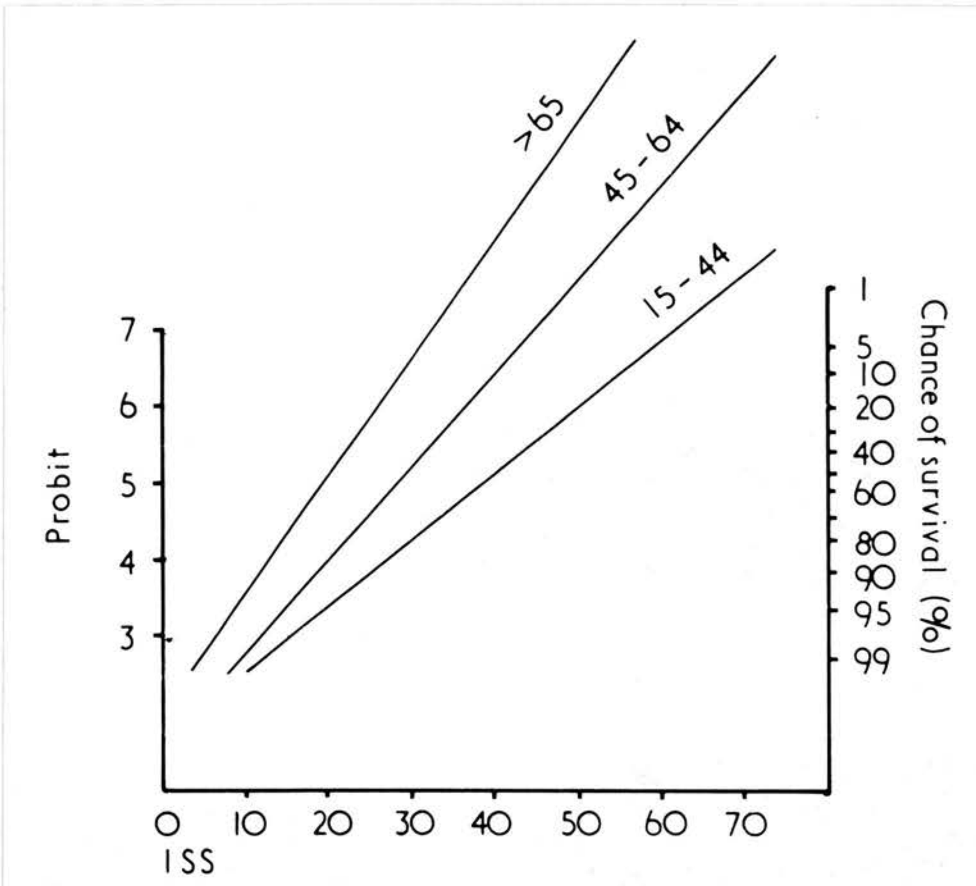

FIGURE 2 - Relation between Injury Severity Score and survival. Yates' (1977) modification of Bull's (1975) Probit lines.

Probit lines have been extended to allow translation of scores for younger and older age groups on to the line representing middle age group.

ISS	Age (yr) 15<25	25<35	35<45	45<55	55<65	65<75	75<85
55<60	1·0	1·0	1·0	1·0	1·0	1·0	1·0
50<55	0·9	0·9	1·0	1·0	1·0	1·0	1·0
45<50	0·7	0·8	0·9	1·0	1·0	1·0	1·0
40<45	0·6	0·7	0·8	0·9	1·0	1·0	1·0
35<40	0·4	0·5	0·6	0·8	0·9	1·0	1·0
30<35	0·3	0·3	0·5	0·6	0·8	0·9	1·0
25<30	0·2	0·2	0·2	0·4	0·7	0·8	0·9
20<25	0·1	0·1	0·1	0·2	0·3	0·5	0·8
15<20	0	0	0	0·1	0·1	0·3	0·5
10<15	0	0	0	0	0	0·1	0·3
5<10	0	0	0	0	0	0	0·1
0< 5	0	0	0	0	0	0	0

FIGURE 3 - Probability of mortality for different combinations of Injury Severity Score and age, Bull (1978).

Although the author recognised that this was an oversimplication of the effects of multiple trauma, the index has been validated for a number of outcome measures including mortality, length of hospital stay and requirement for ventilatory assistance (Goldberg, 1984).

2.5 Physiological Severity Indices

2.5.1 Introduction

An alternative to the anatomical injury severity indices are scales which are based either on clinical signs or physiological measurements or a combination of both. Severity scoring derived from physiological variables has represented a powerful clinical and research tool in intensive care units (Morgan & Branthwaite, 1986). However, systems such as the Therapeutic Intervention Scoring System (TISS) (Cullen et al., 1974) and the Acute Physiological and Chronic Health Care Evaluation (APACHE) classification (Knaus et al., 1981) are complex and although several simplifications have been devised (Bion et al., 1985) they are difficult to apply in the pre-hospital setting.

Simpler physiologically based scales have evolved primarily to assist the process of triage by paramedic personnel attending accident scenes (Champion, 1982). An estimate of the injury severity in terms of the patient's probability of survival, aids the identification of the high risk patient and thereby determines the steps that have to be taken to match existing resources to patient needs. In addition to facilitating the process of triage, physiological severity indices may be used to predict mortality and thereby provide a method of evaluating trauma care systems (Champion et al., 1983).

2.5.2 The Glasgow Coma Scale

One of the most widely used prognostic scales, calculated from simple variables determined by clinical examination, is the Glasgow Coma Scale (Teasdale & Jennett, 1974). Information has been derived from a data bank of more than 1,000 patients with head injury, by relating the severity of the initial insult to subsequent outcome (Jennett et al., 1979) and this information has been used to compare the results of different forms of treatment (Jennett et al., 1980). Clearly the Glasgow Coma Scale only addresses the consequences of injury in one body region. One of the criticisms of the Injury Severity Score however, has been the difficulty in classifying head injury (Gilmore et al, 1981). Mayer and co-workers (1980) developed a modified Injury Severity Scale (MISS) which utilised the categories of the AIS but classified neurological injuries according to the Glasgow Coma Scale. MISS has subsequently been reported to be an accurate predictor of morbidity and mortality in multiply injured patients (Mayer et al., 1984).

2.5.3. The Trauma Index

Kirkpatrick & Youmans (1971) developed the Trauma Index as a rapid and simple means of classifying injured patients by paramedics at the scene. The scale has five parameters (region, type of injury, cardiovascular, CNS and respiratory status) each with four categories of severity. Assessment is based on subjective clinical judgement and confusion may arise for example in the CNS category, differentiating between "drowsy" and "stupor". Although the index has been field tested (Ogawa & Sugimoto, 1974) it is considered too unreliable for research purposes (Gibson, 1981).

2.5.4 The Triage Index and Trauma Score

In developing the Triage Index, Champion and co-workers (1980b) initially identified 16 variables within the cardiorespiratory and central nervous systems. A subset of five variables that could best predict mortality was then determined using logistic regression analysis; respiratory expansion, capillary refill and the three elements of the Glasgow Coma Scale (eye opening, verbal response and motor response). The Triage Index was subsequently modified to include two routinely measured parameters, the respiratory rate and blood pressure. Weighted values for each parameter are summated to obtain the 16 point Trauma Score (Champion et al., 1983). The Trauma Score has been correlated with patient outcome in nearly 4,000 trauma patients (Champion, 1982). An important application of the Trauma Score is in combination with the Injury Severity Score, when comparisons can be made between predicted and actual patient outcome, thus providing a useful index of patient care - the TRISS methodology (Trauma Score, ISS, age combination index) (Champion et al., 1983).

2.5.5 CRAMS Scale

Gormican (1982) considered the Trauma Score relatively complex for field use and devised a simple scale that is numerically similar to the Apgar score. The anacronym "CRAMS" represents the five components measured: circulation, respiration, abdomen, motor and speech. Up to two points were awarded for each category depending on whether the component is normal (2), mildly abnormal (1), or severely abnormal (0). Although such a scale has been reported to differentiate between "minor" and "major" trauma, serious inaccuracies can arise from the abdominal and thoracic examination at the scene. In addition, the scale has not been correlated with mortality and is not of proven reliability (Champion, 1982).

2.5.6 Pre-hospital Index

The most recent addition to the triage orientated scoring systems is the Pre-hospital Index (PHI) (Koehler et al., 1986). Because of the difficulty in accurately examining the chest and abdomen associated with the CRAMS Scale, these components have been eliminated from the PHI. The score comprises four parameters; systolic blood pressure, pulse, respiratory status and level of consciousness, each of which are scored 0 to 5. The index has been field tested on a prospective basis and found to be a statistically significant pre-hospital indicator of trauma severity.

2.6 Injury Severity Indices to Evaluate Accident Flying Squads

The introduction of severity indices has provided methods of objectively assessing the patient with multiple injuries. By providing quantitative measures of severity and allowing for differences between patients' injuries and the combined effects of these injuries, assessment of the quality and outcome of emergency care can be made.

Indices used to evaluate the pre-hospital treatment provided by Accident Flying Squads should primarily reflect the severity of the initial insult to the body. Indices based primarily on physiological data are handicapped in this respect; BP, pulse and respiratory rate may initially be normal following recent trauma to patients who subsequently die from a ruptured aorta or severe intracranial bleed. Hennemann (1987), has claimed that data presented by Morris et al. (1986), on the application of the Trauma Score in the pre-hospital setting, clearly indicates that scores based on physiological data cannot be expected to be sensitive.
If used therefore for evaluating pre-hospital care the index would certainly have to be combined with an anatomical measure of severity. A further difficulty arises in relation to the accurate determination of physiological parameters at accident scenes. Flying

Squads are often summoned when there is delay in the transfer of a patient as a result of entrapment. Initial access to the patient is often restricted and immediate overall assessment is therefore impossible. Some parameters such as capillary refill and respiratory rate may also be difficult to determine when the lighting is poor and may also be affected by temperature.

A severity index based on anatomical injury eliminates these difficulties and although unable to be computed at the scene, does reflect the initial insult. Unfortunately, the ICD codes do not differentiate degrees of severity sufficiently and any index based on this system has been shown to be inferior to that based on the AIS (Goldberg et al., 1984). The Abbreviated Injury Scale is reliable, well validated for a number of outcome measures and coding can generally be accomplished within 24 hours. The Injury Severity Score based on the AIS was therefore considered to be the index of choice for quantifying the injuries of patients treated by the Accident Flying Squad.

CHAPTER 3

ORGANISATION AND FUNCTION

Detailed accounts of the organisation and function of hospital based Accident Flying Squads have been provided in previous theses (Snook, 1974; Little, 1976). It is therefore proposed only to outline the Edinburgh scheme and to review the recent literature on equipment used by the squad.

3.1 Flying Squad Team

The Flying Squad personnel comprises staff from the Accident and Emergency Department, Edinburgh Royal Infirmary. The usual team consists of a senior member of medical staff (Consultant or Registrar grade), one Senior House Officer and one or more experienced nurse, while the vehicle is driven by ambulance personnel.
There is no reliance placed upon members of staff from any other department such as anaesthetics, avoiding the difficulties that arise from such a system (Collins, 1966; Little, 1976). There are several inherent advantages of using personnel from the Accident and Emergency Department. All members are continuously available and the squad can therefore be rapidly mobilised on a 24 hour basis. The staffing of the

department is such that the complement of staff in the base department is not depleted and adequate cover is provided. The team is well rehearsed in resuscitative techniques used within the department and can adapt such techniques to conditions encountered at the scene. There is also continuity of care from the scene through the Accident and Emergency Department until the the patient is admitted to a specialist unit. Members of staff are already acquainted with emergency services personnel through the day to day work of the department and therefore the "team" approach to any incident is enhanced. In addition, the attendance of an Accident and Emergency medical team at the scene improves the first hand experience gained in witnessing mechanisms of injury. This has implications both for the management of the patients and the initiation of preventative measures.

Protective multithene jackets and trousers are provided for the team which are light weight and waterproof. The members of the team are easily identified at the scene even in poor lighting conditions and this facilitates communication (Fig. 4). Flying squad personnel are all adequately insured against personal injury sustained during a call-out.

The function of the team is to provide a high level of resuscitative care at the incident scene and during transfer to hospital, to provide analgesia (including splintage) and to assist in the extrication and release of trapped casualties. In the Lothian area, the Flying Squad has the additional role of providing the site incident medical team in the event of a major disaster. The function of hospital mobile medical teams at a major incident has been emphasised by Savage (1970) and reviewed by Finch & Nancekievill (1975).

3.2 Transport

Flying squads have utilised a variety of transport systems. Large mobile surgical theatres operating in the United Kingdom and Germany in the 1960s were found to be cumbersome and soon abandoned (Gögler, 1965; London, 1982). When the Derby Flying Squad first became operational in 1955, use was made of a taxi service to transport the team but the limitations soon became apparent (Collins, 1966). Transport of the Flying Squad teams and equipment, utilising police cars (Little, 1976) and ambulance vehicles (Hall, 1965; Hindle et al., 1975) and single handed schemes using private cars have been described (Snook, 1969b). Only six centres in the United Kingdom operate their own Flying Squad vehicle (Bodilwala, 1982). This may take the form of estate cars (Brett, 1980) which are also used in France (Drouet, 1982a, b) or specially modified

Figure 4 - Flying Squad team.

Team members wearing yellow multithene jackets are readily identified at the scene.

ambulance vehicles (Carew-McColl, 1985). Helicopters are an integral part of the system of pre-hospital medical care in the United States (Cowley et al., 1973; Cleveland et al, 1976; MacKenzie et al, 1979), Germany (Echtermeyer, 1985a, b) and Australia (Stevenson, 1986). Only one centre in the United Kingdom utilises helicopter transport for their Flying Squad (Selwood, 1987).

The Edinburgh Flying Squad vehicle is a specially modified commercial van and is operated in collaboration with the Scottish Ambulance Service (Fig. 5). The vehicle was purchased from donations by readers of the Edinburgh Evening Newspaper to mark the 250th Anniversary of the foundation of the Royal Infirmary of Edinburgh.

The van is capable of transporting five personnel (including the ambulance driver) whilst equipment is stored in the rear of the vehicle. There is no facility for the transport of patients. The vehicle is based outside the Accident and Emergency department where mains electrical power provides battery charging for all instruments and also maintains the internal temperature of the vehicle at 65°F. Two audible alarms are fitted, loud 2 tone horns and an American style yelper/siren. In addition public address is available, made from the van if required.

FIGURE 5 - The Edinburgh Flying Squad vehicle.

3.3 Communications

The Flying Squad responds to a request for attendance by any of the emergency services or a doctor at the scene of an accident or medical emergency. The majority of calls are subsequently relayed from ambulance control via a direct radio link to the Accident and Emergency Department. On receipt of the call the team is assembled by the nurse in charge and the Flying Squad mobilised on the arrival of the ambulance driver. The vehicle is equippped with a multichannel ambulance radio allowing communication with ambulance control and directly with the Accident and Emergency Department. This system facilitates re-direction en route and rendezvous with an ambulance transferring a patient to hospital from the scene. In addition, UHF hand held sets allow communication between members of the team at the scene.

3.4 Equipment

3.4.1 Introduction

Considerable experience has been gained with respect to the nature of resuscitative equipment necessary for the provision of immediate medical care at the scene (Aston, 1969; Snook, 1974; Baskett et al., 1976; Jacobs &

Berrizbeitia, 1984; Silverston, 1985). Usually the equipment is assigned for use specifically by the Flying Squad and adapted for the designated vehicle. Over the past decade such equipment has become progressively more refined, sometimes as the result of innovations made by members of Flying Squads (Redden & Little, 1973; Snook, 1972b). A considerable proportion of casualties are trapped and extrication requires special equipment. This is normally carried by fire service vehicles although several squads carry a limited range of hydraulic rams, saws, shears and jacks (Snook, 1969a).

The Flying Squad aims to provide rapid and essential care at the scene and not complex medical or surgical intervention (Little, 1972). Provided the basic priorities of airway patency, ventilation, volume replacement, pain relief and splintage can be achieved little more is required in the vast majority of cases before transfer to hospital. The corollary of this is that it is not too expensive to fully equip a Flying Squad; £10,000 - £15,000 would be sufficient today (Robertson & Steedman, 1985).

3.4.2 Principles of Organisation

The resuscitative equipment carried by the Flying Squad is similar to that used within the department and therefore familiar to staff. Most of the equipment is contained within robust lightweight cases and easily carried by any individual member of the team. Each item has its own place within a foam rubber inlay and the equipment is therefore readily displayed on opening the case (Fig. 6). Separate cases are assigned for use in children. A full list of equipment carried in each case and additional resuscitative equipment is given in Appendices I - IX. To permit easy access to essential equipment on immediate arrival, several cases are stored in the side of the van (Fig. 7) with all other equipment being stored in the rear (Fig. 8). Resuscitative equipment used by the Flying Squad is now discussed in more detail.

3.4.3 Mechanical cardiopulmonary resuscitator

The flying squad carries a Michigan Instrument Life-Aid Resuscitator, which is routinely used by the team for cardiac arrests.

Recognition that manual cardiopulmonary resuscitation (CPR) was tiring and often physically limited lead to the development of mechanised equipment aimed at providing standard CPR (Barkalow, 1984). Despite initial interest, reports on the use and efficacy of such devices in the United Kingdom remain limited

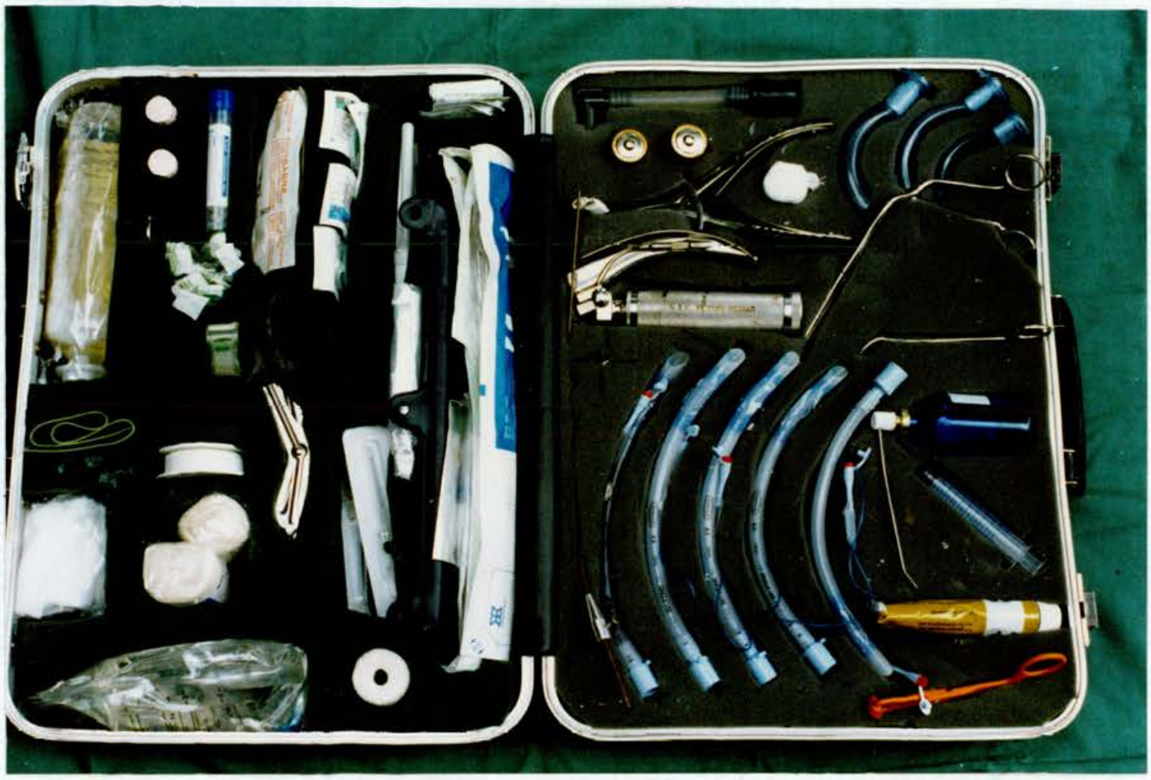

FIGURE 6 - Resuscitation case.

Equipment is readily displayed within the foam rubber inlay.

FIGURE 7 - Near-side view of vehicle.

Side door allows immediate access to essential resuscitative equipment on arrival at scene.

FIGURE 8 - Rear storage of equipment

(Little et al., 1974). Using these machines, mechanical chest compression is comparable to manual techniques when the manual chest compression is performed under optimal in-hospital conditions (Taylor et al., 1978). Clearly in the pre-hospital cardiac arrest situation where conditions are certainly not ideal a mechanical device may offer certain advantages. Although manual chest compression results in greater systolic arterial pressure than mechanical chest compression, mean arterial pressure is higher with the mechanical technique (McDonald, 1982). Since mean arterial pressure provides a more accurate reflection of flow, mechanical techniques may be considered to provide optimal chest compression.

A Thumper Cardiopulmonary Resuscitator Model 1004 has been used for cardiac arrests within Accident and Emergency Department with good results (Robertson & Little, 1984) and has also been successfully used in prolonged out-of-hospital cardiac arrest (Mackay et al., 1987).

3.4.4 Medical anti-shock trousers (MAST)

The MAST suit has become a standard component of pre-hospital treatment in some countries (American College of Surgeons, 1981) but its current role remains controversial (Kaback et al., 1984). The first documented use of a pneumatic anti-shock garment for the field management of trauma patients was during the Vietnam War (Cutler & Daggett, 1971) and was translated into civilian pre-hospital practice by Kaplan and co-workers (1973). Subsequent case series have concluded that MAST are safe and effective in the pre-hospital stabilisation and management of trauma patients (Lilja et al., 1975; Civetta et al., 1976; McSwain, 1977; Pelligra & Sandberg, 1979; Wayne & MacDonald, 1983).

The pre-hospital situations in which anti-shock trousers have been used can be grouped into three categories; management of shock, stabilisation of fractures and arrest of haemostasis (Kaback et al., 1984). They have been used to manage traumatic retroperitoneal haemorrhage (McLaughlin et al., 1972); to treat gun shot wounds, fractures of the lower limbs and stab wounds (Kaplan et al., 1973); in massive abdominal trauma (Cutler & Daggett, 1971); for bleeding above the diaphragm (Lilja et al., 1975; Wasserberger et al., 1981); in haemorrhage associated with severe pelvic fractures (Flint et al., 1979) and in the management of intra-abdominal bleeding from aneurysms (Espinosa & Updegrove, 1970). Mahoney & Mirik (1983) have in addition shown that fully inflated MAST can be a useful adjunctin the treatment of refractory out-of-hospital cardiac arrest. Until recently the literature suggested that the beneficial effect of MAST was mainly due to a redistribution of blood from the area under the trousers to the area above (750-2000 ml) (McSwain, 1976; American College of Surgeons, 1977; Wilder & Barber, 1979). However recent studies suggest that this volume of transfusion is much smaller (Gaffney et al., 1981; Bivins et al., 1982; Lee et al., 1983). An alternative explanation for the elevation in blood pressure following inflation of MAST is a general pressor response resulting in an increase in the total peripheral resistance (Goldsmith, 1983; Niemann et al., 1983) although there is no recordable increase in the level of circulating catecholamines. An autotransfusion effect resulting from movement of tissue fluid into the circulation following a net change in pressure beneath the MAST seems unlikely (Randall et al., 1984).

The application of MAST is not without potential adverse effects. Following prolonged application ischaemic limb damage can occur (Maull et al., 1981; Durand et al., 1982; Bass et al., 1983). Even at low pressures MAST can result in a decrease in renal perfusion and urine output (Shenasky & Gillenwater, 1972; Laughlin et al., 1980). Respiratory embarrassment can result from close proximity of MAST to the costal margin (Ransom & McSwain, 1978; McCabe et al., 1983) and a metabolic acidosis has been shown to develop after inflation (Wangensteen et al., 1968). Additional problems include the difficulty in clinical examination following application (Silverston, 1980b) and the dangers of rapid MAST decompression (McSwain, 1980).

Despite recommendations by numerous investigators and endorsements by medical organisations for the use of MAST, the clinical evidence supporting its use has been based solely on empirical observations (Mackersie et al., 1984). There has only been one prospective randomised evaluation of a pneumatic anti-shock garment in treating trauma patients (Mattox et al, 1986).
There was no statistically significant difference in evaluation and outcome in 352 patients with a pre-hospital systolic blood pressure of less than 90 mm Hg randomised to receive treatment with MAST or "no MAST". It should be noted however that in this study 80% of injuries were produced by penetrating wounds.
As a result, Bodai and co-workers (1987) have recommended abandoning the use of MAST trousers in favour of a "load and go" policy. MAST use is still recommended for patients requiring longer transport times (greater than 20-30 minutes) with specific injuries such as pelvic factures and fractures with bleeding in the lower limbs. An important consideration when pre-hospital transport is provided by helicopter, is an increase in MAST pressure following a

climb in altitude (Sanders & Meislin, 1983).

3.4.5 Anaesthesia and Analgesia

Although the "roadside" is not the place for complex intervention it has been recommended that Accident Flying Squads should be capable of full anaesthetic practice to allow surgery for the otherwise impossible release of a victim (Little, 1972). A review of anaesthesia "in the field" and the development of the Derby Lipaco Anaesthetic machine which was specifically designed for use by Flying Squads has been reported by Redden & Little (1973). An alternative to inhalational anaesthesia in difficult situations was initially suggested by Phillips et al., (1970) using intravenous Ketamine. Subsequently this was used successfully in the Moorgate underground disaster to facilitate the amputation of a patient's foot at the scene (Finch & Nancekievill, 1975) and more recently was found to be very useful in the Falklands campaign (Jowitt, 1984).
The squad also carries an Entonox apparatus. Self-administered mixture of 50% nitrous oxide and 50% oxygen for pain relief has been used extensively in the pre-hospital setting both in the United Kingdom (Baskett & Whithnell, 1970; Wright et al., 1972; Snook, 1969a) and North America (McKinnon, 1981).

According to the recent literature however, the cardiovascular effects of nitrous oxide are probably more pronounced than was once thought (Lichenthal et al., 1977; Thorburn et al., 1979; Kawamura et al., 1980). However the data is conflicting and conclusions difficult to draw. Some studies have supported the claim of insignificant cardiovascular effects (Craythorne & Darby, 1965; Kerr et al., 1975). Others have shown decrease in cardiac output with maintenance of normal blood pressure, probably due to a primary or secondary alpha-adrenergic effect of nitrous oxide on peripheral vascular resistance (Eisele & Smith, 1972; Thornton et al., 1973). Conversely Kawamura and co-workers (1980) have shown an increase in cardiac output with decrease in systemic vascular resistance with no change in the blood pressure.

Despite the variability of these findings, the clinical evidence to date generally supports the safety and efficacy of this system of analgesia for pre-hospital use (Baskett, 1972; Kerr et al., 1975; Montgomery et al., 1980).

CHAPTER 4

AIMS, METHODS AND STATISTICAL TESTS

4.1 Aims

Hospital based Accident Flying Squads have provided emergency care within the United Kingdom for over 30 years. However, there has been little objective assessment to confirm the many subjective judgements of benefit and despite the introduction of new resuscitative techniques and equipment there has been no detailed account of the role of such squads since the early 1970s. The introduction of injury severity scoring has now permitted a quantitative evaluation of patient care in trauma. The aims of this study are therefore -

1. To describe the profile of the hospital based Accident Flying Squad; the pattern of workload and treatment provided at the scene.
2. To objectively evaluate the efficacy of an Accident Flying Squad utilising an Injury Severity Scoring System.

4.2 Methods

The results reported in this thesis are based on a six year study, January 1981 - December 1986, when the author was a member of the Accident Flying Squad based at the Royal Infirmary, Edinburgh. Patients included in the analysis were those attended by the team at the scene or on rendezvous with the ambulance. After each call-out the following information was documented:

- Date and time of call.
- Source of call.
- Geographical location.
- Type of incident.
- Mobilisation time.
- Duration of call.
- Number of patients attended.

The following details were recorded for each patient:

Age		
Sex		
Diagnosis	Medical case	Primary diagnosis
		Primary arrhythmia
	Trauma case	Mechanism
Treatment	Airway	
	Venous cannulation	
	Volume infusion	
	Analgesia	
	Medical anti-shock trousers	

Mechanical chest compression

Medication

Extrication or release

Outcome

For trauma patients, all injuries were initially recorded from clinical and radiological findings. Further information was obtained as necessary from in-patient case notes following operative intervention or from post-mortem reports. Each injury was then assigned a code from the Abbreviated Injury Scale dictionary and Injury Severity Scores subsequently derived.

In mortality studies, Injury Severity Scores must be weighted for age. In this study age weighting was produced by correcting the ISS value of patients to that appropriate to the 45-64 age group using Yates' (1977) correction of Bull's (1975) probit lines.

4.3 Statistical Tests

The Abbreviated Injury Scale is a ranking scale (1-6) and the quantitative relationship of the AIS codes is non-linear (Joint Committee on Injury Scaling, 1985). The authors caution against averaging AIS codes which of course is only valid if the ratings are linear. The ISS scale likewise is discontinuous, with 44 stages between 1 and 75; the gaps becoming more frequent as the scores approach the maximum possible value of 75 (Stoner et al., 1977). The description of overall severity in groups by non-integral values such as the mean has therefore no precise meaning and is inappropriate and misleading. Mean values can give a qualitative indication of trend when comparing large groups but may give very distorted impressions of smaller groups, owing to a skewed distribution. This arises because there are usually more patients with minor (ISS less than 5) than with moderate injuries (ISS 5-12) and many more than with severe injuries (ISS greater than 12). In this study the injury severity for groups of patients have therefore been described in terms of the median value and the range. However caution must also be exercised in using the median. The method of deriving the ISS from the AIS produces scores between 1-75 which are common e.g. 1, 4 and 9. Consequently there may be a tendency for groups that are dissimilar to have the same median.

The Injury Severity Score and the Abbreviated Injury Scale can however be used to characterise cells for the chi-square test either by single values or by ranges according to the number in the groups to be compared (Heath, 1985). This method was used to compare groups of patients in this study and Yates' correction factor was applied for small numbers. Wilcoxon rank sum test was also used on unpaired data. Mean values are provided for normally distributed data along with the standard deviation.

4.4 Baseline chi-square analysis

Probit analysis has become widely accepted as the best method available for comparing the results of different techniques for burn therapy (Stern & Waisbern, 1976). Units that treat relatively few patients can make valid comparisons of their results to baseline mortality curves derived through Probit Analysis from larger series of data (Waisbern et al., 1975). When the percentage surface area of burn is taken as the index of severity and plotted against the observed mortality a sigmoid relationship familiar in toxicity studies is derived. The Probit statistical method which is based on deriving the sigmoid from the "normal" distribution of susceptibility to injury, fits a straight line to such data. Probit Analysis (Finney, 1947) assigns large weights to severity groups with many patients and to groups with moderate injury that result in mortality rates in the 30-70% range (Stern & Waisbern, 1976). The resulting regression line can be completely specified by the point that it intercepts the vertical axis and its slope.

Burns are surface injuries and lend themselves to direct measurement. Area of burn as "dose of injury" has been noted to relate well to mortality and by Probit Analysis LD50s can be calculated for different areas of burn at different ages (Bull & Squire, 1949). The proposal by Baker et al. (1974), of an Injury Severity Score for multiple injuries and the similarity of its relation to mortality and age suggested that such a measure was analogous to surface area in the case of burns. This led Bull (1975) to explore this possibility and in an analysis of 1333 road traffic accident victims treated at the Birmingham Accident Hospital, he found that the technique of Probit Analysis for trauma patients as assessed by ISS values, was similar to that for burns as assessed by surface area. The LD50s for young adults, middle age and elderly groups were found to be ISS 40, 29 and 20 respectively for road injuries and 56, 40 and 17% surface area for burns.

Thus a baseline mortality curve was available for trauma and was used in the present study to derive a mortality expectancy for the groups of patients treated by the Edinburgh Flying Squad. It must be emphasised that any baseline comparison involves matching the actual experience of one particular unit with an abstract measure of mortality and is not the same as comparing the Flying Squad experience with that of the Birmingham Accident Hospital directly.

A number of methods are available to facilitate comparison with a baseline curve (Flora, 1978), one of which is the chi-square (chi^2) analysis described by Stern & Waisbern (1976). This method compares the observed and predicted frequencies with which data points fall into each of several groups. The following formula is used to calculate the chi-square increment for each group

$$I = \frac{(d - np)^2}{np\ (1-p)}$$

I = chi-square increment
d = number of deaths
n = total number of patients in group
p = predicted mortality from Bull's (1978) mortality grid

The chi-square increments are then summated and the sum checked against those corresponding to different levels of significance for the chi-square distribution, with the degrees of freedom equal to the number of injury groups that actually contain patients. Statisticians generally hold suspect any large chi-square increment that is calculated for injury groups which have a predicted number of deaths less than 5 (Stern & Waisbern, 1976).

Throughout this thesis differences were considered significant for p values < 0.5.

RESULTS

5.1 Profile of the Flying Squad

An analysis has been made of call-outs occurring during a six year period since the squad first became operational in January, 1981.

5.1.1 Number of Calls

There have been 459 requests for the attendance of the Flying Squad at the scene (fig. 9). There was an initial decline in the frequency of call-outs during the first three years. However, since 1984 there has been a dramatic increase, with the number of call-outs doubling from 1983 to 1984 and during 1986 there were three times as many call-outs compared with 1981.
During the first year of the squad's operations 21.6% of call-outs (11) were aborted, either prior to leaving the Accident and Emergency Department or en route to the scene. As the emergency services became more familiar with the function of the squad, the proportion of aborted calls decreased. The 14 aborted call-outs in 1986 included 7 call-outs to "full emergency" alerts at Edinburgh airport.

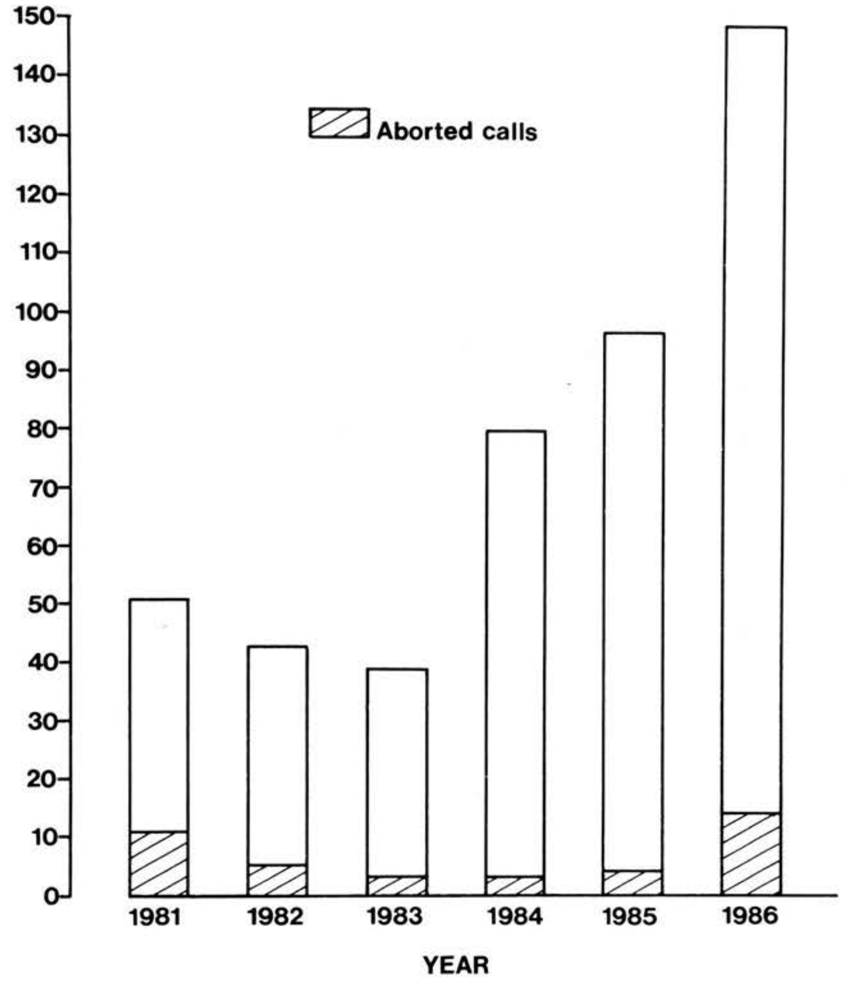

FIGURE 9 - Yearly distribution of call-outs.

5.1.2 Location of call

The area served by the Flying Squad includes the city of Edinburgh, the Lothian region and the Border region comprising the whole of the Berwick district and parts of the Ettrick, Lauderdale and Tweeddale districts. The city boundary is at an approximate radius of 4 miles (7 km) from the hospital base of the Flying Squad and the area served stretches up to 50 miles (80 km) in some directions. Ninety-six call-outs (21%) were to locations outwith the city boundary, comprising 73 trauma calls and 23 medical calls (fig. 10). There were in addition 17 calls to Edinburgh airport which lies just outwith the boundary. The furthest distance travelled was 46 miles (74 km) to reach a patient trapped beneath an overturned crane. Within the city boundary there were 188 medical calls and 154 trauma calls. The median Injury Severity Score for patients attended following calls outwith the city boundary was 17 and 14 for those within the city boundary, but the distribution of scores was not significantly different, (Table 1). In 27 call-outs the Flying Squad rendezvoused with the ambulance en route to hospital. In 25 such call-outs (92%) the patient(s) was being transported from a rural accident scene when the estimated time of arrival at hospital was in excess of 30 minutes. The potential benefit of rendezvous in decreasing the time to definitive care is illustrated in fig.11.

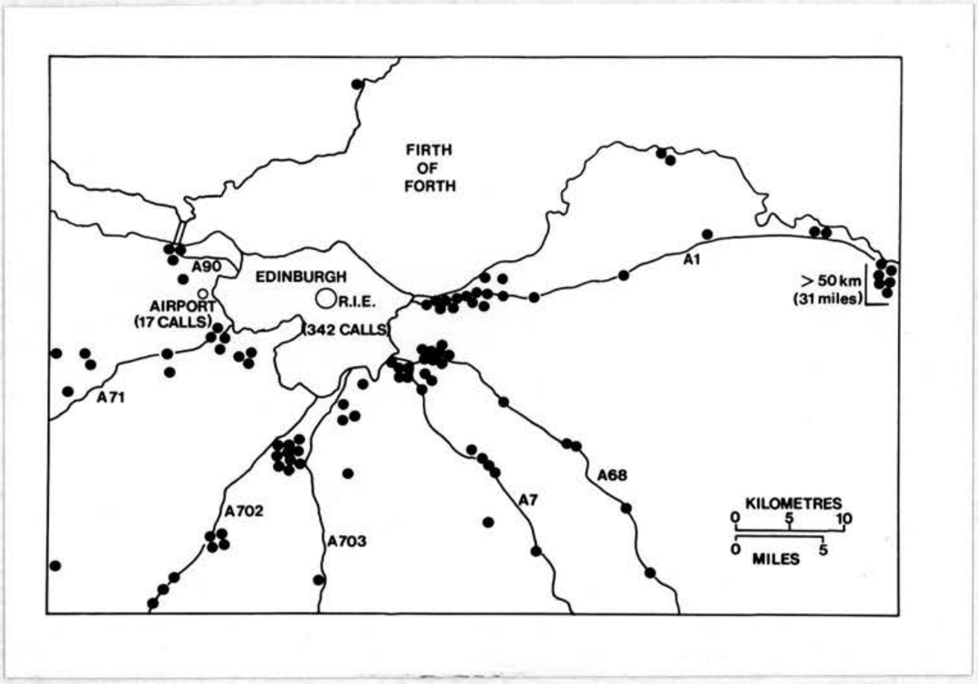

FIGURE 10 - Location of call-outs.

	No. of Patients	
ISS Cells	Inside City	Outside City
1-4	24	12
5-9	43	14
10-14	18	13
15-19	12	11
20-29	29	15
30 or >	41	26
TOTAL	167	91

$chi^2 = 5.64$, df = 5, $p > 0.10$

TABLE 1 - Severity of injury in patients attended by the Flying Squad at the scene of the accident located within and outwith the city boundary.

FIGURE 11 - Rendezvous with ambulance (call 400)

Following rendezvous, two road traffic accident victims were examined in the ambulance which had an estimated time of arrival at hospital of 20 minutes. One patient (ISS=9) had an intravenous infusion established and the second patient (ISS=45), who was in severe respiratory distress with bilateral tension pneumothoraces, had bilateral chest drains inserted. (call 381).

5.1.3. Type of Call

Table 2 illustrates the type of call the Flying Squad responded to. Although the Flying Squad is designated by the prefix "Accident", a considerable and rising proportion of their workload are medical cases. The rise in the number of medical call-outs has largely contributed to the overall increase in the use of the Flying Squad and indeed in 1985 and 1986 medical call-outs superceded calls to accidents.

In response to a full emergency alert from Edinburgh airport, the Flying Squad is mobilised with view to providing a site medical team should an aircraft accident or incident occur. In all instances (17 calls) the team was stood down en route. Only 3 hoax calls (0.6%) were identified. The call-out to a major disaster exercise and the 3 hoax calls are not include in any further analysis.

5.1.4 Mobilisation and duration

The mean mobilisation time ($\pm$ SD) (time from receipt of call in the Accident and Emergency Department to dispatch of the Flying Squad) was 3.7 minutes ($\pm$ 2.7). In 1983 when the mean mobilisation time was 4.6 minutes there was a higher proportion of calls between 0200-0800

YEAR	TRAUMA	MEDICAL	AIRPORT ALERT	HOAX	TOTAL
1981	37	11	3	-	51
1982	31	11	1	-	43
1983	20	15	1	2	38
1984	42	34	4	-	80
1985	35	60	1	1	97
1986	62	80	7	-	149

(+ 1 call-out to a major disaster exercise, 1983)

Table 2 - Type of Call.

hours when the covering registrar may have been on-call from home resulting in this delay (Table 3). The mean duration of call-out ($\pm$ SD), from the time of leaving the department to the time of return was 44.3 minutes ($\pm$ 27.8). The mean duration of call-out for each year is given in Table 4. The longest call-out (310 minutes) was to assist in the transfer of a patient with a myocardial infarction aboard a U.S. Navy destroyer, fogbound in the River Forth (the team were taken to the scene by the local coastguard). Eighty-five per-cent of the call-outs lasted less than one hour.

5.1.5 Time of Day

Fig. 12 illustrates the pattern of call-out throughout the day. Calls to road traffic accidents increased during the day with a peak during the evening "rush hour" and a further peak shortly after midnight. Medical call-outs reached a peak during the afternoon.

YEAR	MEAN TIME (mins)	$\pm$ SD	% CALLS 0200-0800 hr
1981	4.1	2.5	13.4
1982	3.0	1.6	7.7
1983	4.6	3.2	14.7
1984	3.9	3.1	12.0
1985	3.3	2.9	9.0
1986	3.3	2.7	7.3

TABLE 3 - Mobilisation time.

YEAR	MEAN DURATION	$\pm$ SD
1981	37.2	22.4
1982	35.4	17.4
1983	55.5	52.5
1984	48.9	26.8
1985	45.2	21.0
1986	43.8	26.8

TABLE 4 - Duration of call-out.

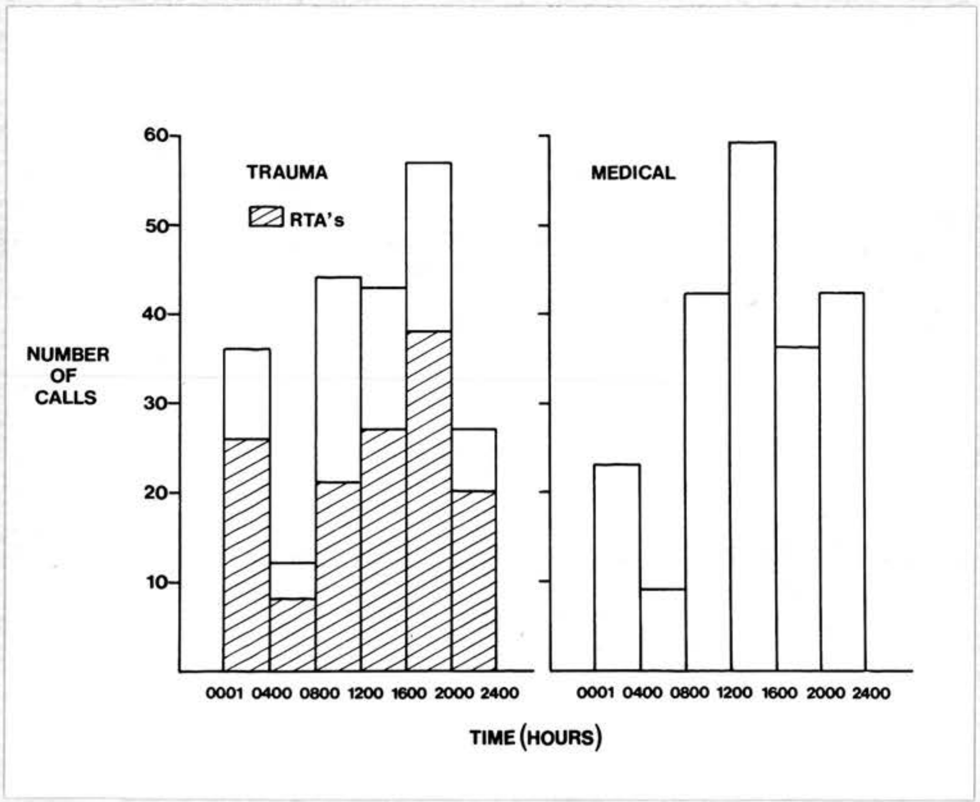

FIGURE 12 - Time of call-out.

5.1.6 Number of patients per call

All medical call-outs involved one patient. Of those call-outs to trauma 77.8% (155 calls) involved one patient; 16.6% (33 calls) - 2 patients; 3.5% (7 calls) - 3 patients; 1% (2 calls) - 4 patients; and 1% of calls (2) involved 5 patients. Although there may have been more patients involved in any one particular accident to which the Flying Squad responded, the numbers relate specifically to those attended by the team.

5.2 Trauma Patients

Between 1981-86 the Flying Squad attended 260 injured patients at the scene (or after rendezvous with the ambulance). One hundred and ninety-two patients (74%) were male and 68 (26%) were female. The mean age ($\pm$ SD) was 35.5 years ($\pm$ 17.7) and the age distribution is given in fig. 13. Fifty per-cent of patients were aged less than 30 years and nearly 70% were less than 40 years.

The median Injury Severity Score for all patients attended was 16 (range 1-75) and the distribution of scores is given in fig. 14. 51.5% of patients attended by the Flying Squad had an ISS 16 or greater. Only one patient could not be adequately scored using the ISS system; A 15 year old boy was trapped beneath a stone slab and died from asphyxia secondary to crush injury.

Two hundred and thirty-eight patients (91.5%) sustained blunt trauma (median ISS = 17) and 18 patients sustained penetrating trauma (median ISS = 5). Three patients with burn injury to the integument had ISS grades of 16, 25 and 75. The mechanism of injury is given in Table 5.

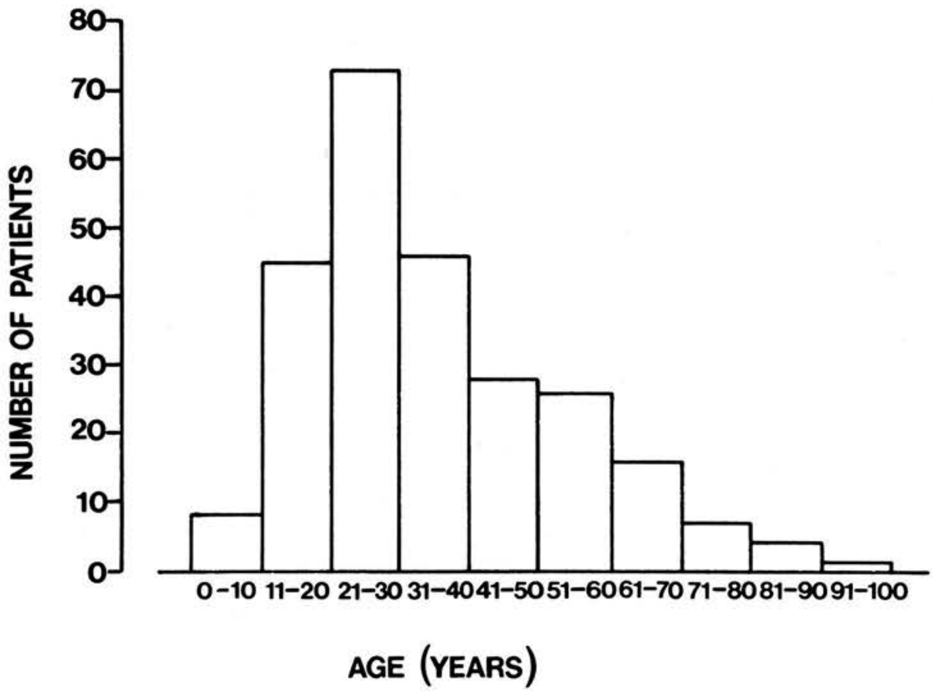

FIGURE 13 - Age distribution of injured patients.

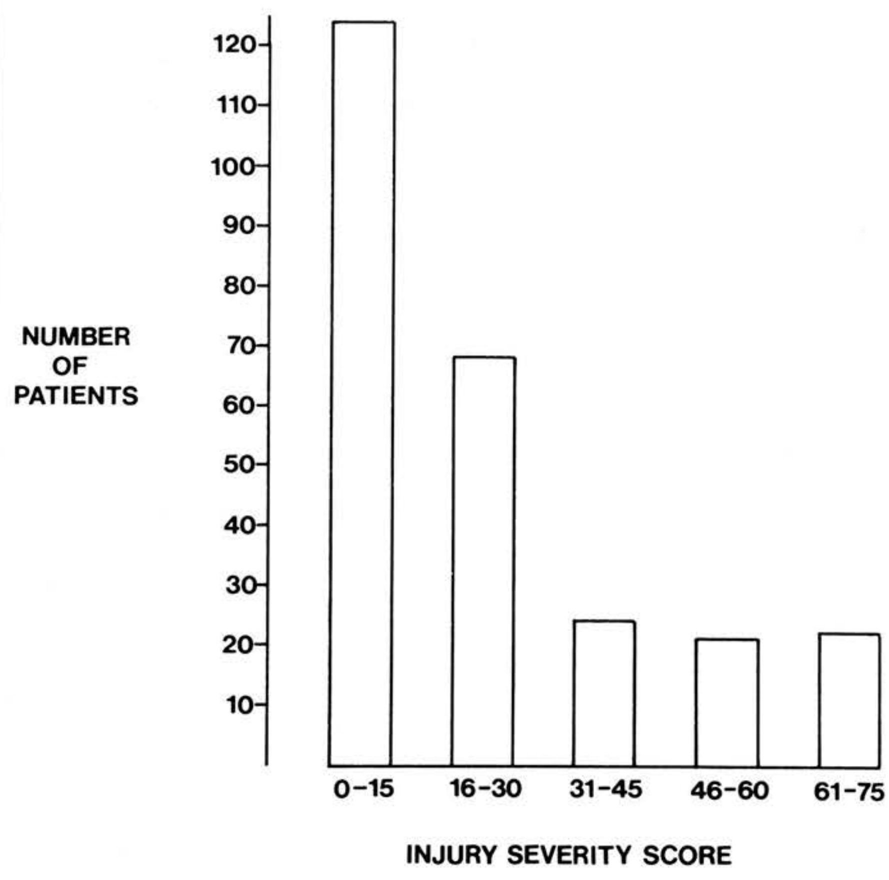

FIGURE 14 - Distribution of Injury Severity Scores.

Mechanism of Injury	No. of Patients	ISS range	Median ISS
Road traffic accident	182	1-75	17
vehicular	(168)	(1-75)	17
pedestrian	(8)	(5-50)	20
motor cycle	(6)	(9-50)	24
Fall	28	1-50	19
Industrial accident	14	4-41	13
Domestic accident	14	1-24	6.5
Suicide	6	4-29	4.5
Assault	12	5-75	21
Burn	3	16, 25 and 75	-

TABLE 5 Mechanism of injury and Injury Severity Scores

5.2.1 Abbreviated Injury Scaling

Table 6 illustrates the distribution of the highest Abbreviated Injury Scale rating in each of the 6 body regions for 259 trauma patients.

Injury to the external integument was recorded in nearly 75% of patients. When an injury involved deeper structures in addition to skin, e.g. compound fracture of a long bone, that injury would be coded under extremities and no code assigned to the external body region. Ninety-four per-cent of integumental injuries were not serious, i.e. AIS less than or equal to 2. Two patients with AIS 5 and AIS 6 respectively had sustained extensive burn injury.

The second most commonly injured AIS body region was that to the extremities including pelvic girdle (fig. 15). Of the 157 patients with injury to this region, 67% had injuries which were AIS $\geqslant$ 3.

Approximately 50% (134 patients) sustained a head injury including injury to the cervical spine. Injury to the head accounted for the highest proportion of injuries (55%) that were considered critical (AIS = 5) or unsurvivable (AIS = 6).

One third of patients sustained injury to the thorax.

ABBREVIATED INJURY SCALE RATING

	1	2	3	4	5	6	Patients No.	(%)
Head	2	54	11	13	43	11	134	(51.5)
Face	15	8	14	12	0	0	49	(18.8)
Thorax	9	10	17	25	17	10	88	(33.8)
Abdomen	2	11	12	8	13	2	48	(18.5)
Extremities	6	40	105	6	0	0	157	(60.4)
External	116	66	7	2	1	1	193	(74.2)
TOTAL	150	189	166	66	74	24		

TABLE 6 - Abbreviated Injury Scale ratings

The Table shows the distribution of the highest AIS rating in each of the 6 body regions for 259 trauma patients.

AIS 1 minor
2 moderate
3 serious
4 severe
5 critical
6 unsurvivable

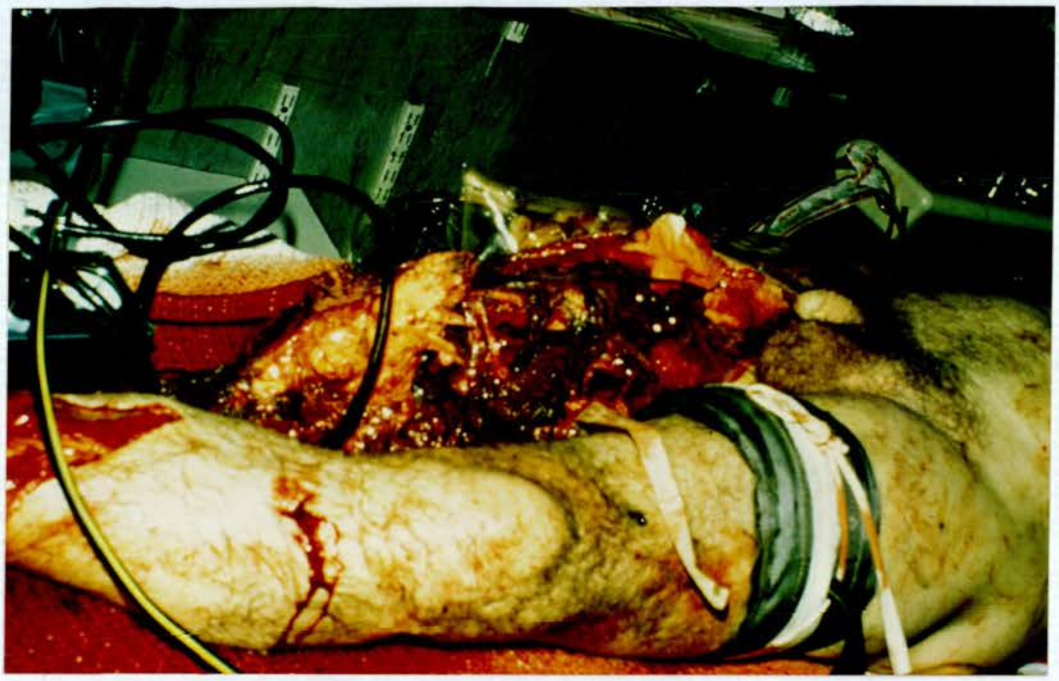

FIGURE 15 - Injuries to the extremities

Call 70. A 57 year old man who was run over by a train.

		AIS	AIS^2
Head	-		
Face	Le Fort III fracture	4	16
Chest	-		
Abdomen	-		
Extremities	R above knee amputation	4	16
	L below knee amputation	3	
	Fracture-dislocation L elbow	2	
	Fracture R femoral neck	3	
External	Degloving injury L arm	2	4

ISS = 36 (16+16+4)

Fifty-nine per-cent of these injuries were AIS$\geqslant$4 which was higher than any in any other body region.

Injuries to the abdomen and face (fig. 16) occurred in approximately one fifth of patients, with AIS$\geqslant$3 coded injuries accounting for 73% and 53% respectively.

5.2.2 Blunt Trauma

Of the 238 patients with blunt trauma, 73% (168) were vehicle occupants involved in road traffic accidents (median ISS = 17). The median ISS of patients with blunt trauma other than vehicular occupants was also 17. The distribution of Abbreviated Injury Scale ratings for vehicular and non-vehicular blunt trauma is given in Table 7. The distribution of severity of injury did not differ between these two groups except for head injury which was significantly more severe in non-vehicular blunt trauma.

Twenty-eight patients were injured as a result of a fall from a height. Eighty two per cent (23 patients) were male and the mean age was 36.3 years (range 2-58 years). Twenty six patients (93%) landed on ground and two patients fell on water. There was a significant relation between severity of injury (ISS) and the height of the fall (fig. 17).

FIGURE 16 - Facial injury.

Case 431. 33 year old man injured by an exploding firework.

Severe disruption of facial skeleton, zygomatic arches, nose, paranasal sinuses and orbits with avulsion of facial soft tissue.
AIS=3.

The patient required intubation to maintain an adequate airway.

	AIS code	Vehicular	Non-vehicular	Total
Head	1-2	49	7	56
	⩾3	54	24	78
	Total	103	31	
		$chi^2 = 5.134$, df = 1, $p < 0.05$		
				Total
Face	1-2	22	1	23
	⩾3	19	7	26
	Total	41	8	
		$chi^2 = 3.050$, df = 1, $p > 0.05$		
				Total
Thorax	1-2	14	5	19
	⩾3	50	19	69
	Total	64	24	
		$chi^2 = 0.034$, df = 1, $p > 0.50$		
				Total
Abdomen	1-2	7	6	13
	⩾3	24	11	35
	Total	31	17	
		$chi^2 = 0.370$, df = 1, $p > 0.50$		
				Total
Extremities	1-2	37	9	46
	⩾3	73	38	111
	Total	110	47	
		$chi^2 = 2.674$, df = 1, $p > 0.10$		

TABLE 7 - Injury severity in vehicular occupants and non-vehicular blunt trauma.

(chi^2 with Yates' correction).

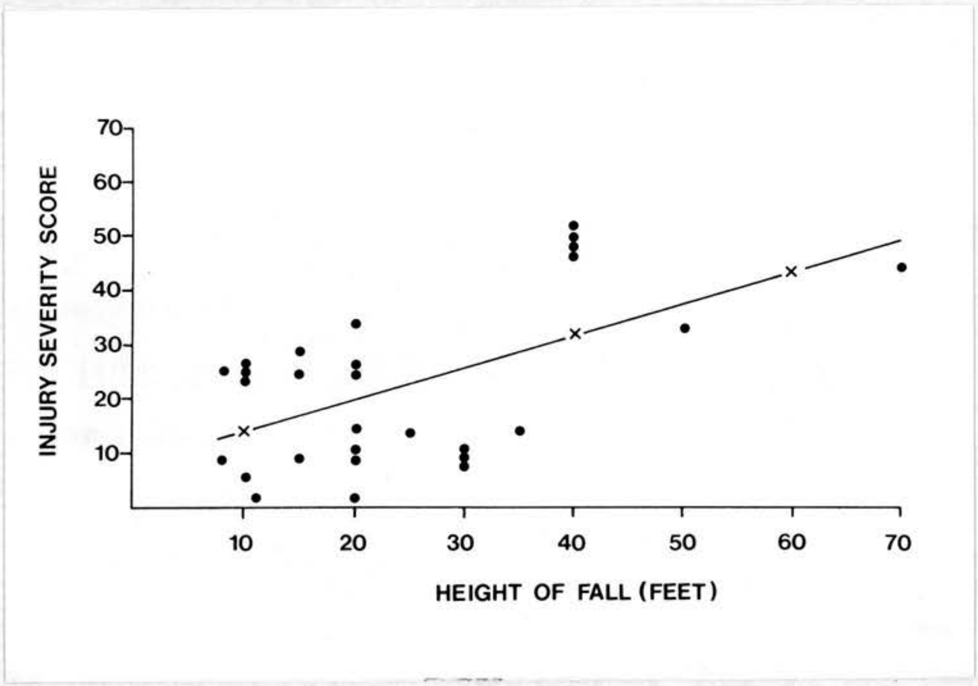

FIGURE 17 - Relation of Injury Severity Score to height of fall.

$r = 0.453, \ p < 0.02$

5.2.3. Penetrating Trauma

Seven per-cent of trauma patients sustained penetrating injury; 12 stab wounds, one gunshot wound and 5 patients were impaled. Fifteen patients (83%) were male and 72% (12 patients) were under the age of 50 years. Seven patients (39%) sustained their injuries as a result of an assault, 5 injuries (28%) were self inflicted and 6 injuries (33%) resulted from domestic accidents. The median ISS was 5 (range 1-75). Four patients died (ISS = 75, 43, 25, 9).

Thoracotomy was performed on only one patient during the 6 year study period; A 21 year old man was stabbed in the precordium and although making a few feeble respiratory efforts at the scene, had no detectable pulse. Following intubation and ventilation and the insertion of a central venous line, a left anterior thoracotomy was performed at the scene. Despite attempts to occlude a right ventricular wound and massage the heart, the patient died on return to the Accident and Emergency Department.

Unsuccessful cardiopulmonary resuscitation was performed on a 40 year old male with a gunshot wound to his chest (AIS = 6) which had shattered the second to eleventh ribs on the right side with partial loss of thoracic wall and extensive damage to underlying lung with associated bilateral pneumothoraces.

A 71 year old man who had partially transected his trachea (ISS = 16), survived following the insertion of a tracheostomy tube. Two patients with Injury Severity Scores of 1 were treated at the scene. Both were impaled and released following local anaesthetic ring blocks.

5.3 Treatment

5.3.1 Intravenous infusion

Intravenous access was established at the scene in 209 patients (81%). A peripheral line was inserted in 156 patients (median ISS = 14) and 38 patients had two peripheral lines (median ISS = 26). Fifteen patients required the placement of a central venous cannula (median ISS = 29). The Injury Severity Scores of patients with two peripheral intravenous lines was significantly higher than those with a single line ($chi^2 = 11.45$, $df = 3$, $p < 0.01$). However there was no statistical difference between those patients with two peripheral intravenous lines and those in whom a central venous line had been inserted ($chi^2 = 2.78$, $df = 3$, $p > 0.10$) (Table 8).

The median Injury Severity Score of patients receiving less than 500 mls of fluid from the time of establishing the infusion to arrival in the Accident and Emergency Department (or to death prior to arrival) was 13. Patients receiving 500-1500 mls had a median ISS of 22 and in those receiving greater than 1500 mls the median ISS was 29. The ISS of patients receiving 500-1500 mls was significantly higher than patients receiving less than 500 mls ($chi^2 = 14.63$, $df = 5$, $p < 0.02$), however there was no significant difference for patients receiving 500-1500 mls compared to those receiving

ISS Cells	1 peripheral line	2 peripheral lines	central line
1-9	63	8	1
10-19	35	8	2
20-29	31	7	5
30 or >	27	15	7
TOTAL	156	38	15

TABLE 8 Frequency distribution of ISS in patients requiring intravenous cannulation.

ISS Cells	500 mls	500-1500 mls	>1500 mls
1-4	16	3	2
5-9	43	4	3
10-14	14	6	6
15-19	14	7	1
20-29	18	10	7
30 or >	22	15	12
TOTAL	127	45	31

TABLE 9 Frequency distribution of ISS in patients receiving volume infusion.

greater than 1.5 litres ($chi^2 = 3.24$, df = 5, $p > 0.50$) (Table 9). Twenty four patients received more than 2 litres of fluid, 13 of whom survived.

5.3.2 Endotracheal intubation

Thirty-nine trauma patients had an endotracheal tube inserted (Fig. 18). Thirty patients were male (76%) and the mean age was 35.9 (range 5-81). The median Injury Severity Score was 43 (range 5-75). Many of the patients were multiply injured; 22 patients had a "critical" head injury (AIS = 5), 7 patients (17.9%) had severe facial injury (AIS = 4) and 17 patients (43%) had severe or critical chest injury (AIS 4 or 5).

Ten patients requiring intubation at the scene survived, median ISS = 34 (range 16-50). Of the survivors 8 were intubated following head injury associated with depressed conscious level (all AIS = 5). In addition two of these patients had sustained severe facial injury. One patient with severe facial injury (AIS = 4) but with no alteration in conscious level required intubation to maintain a patent airway. Of the two remaining patients who survived, one required the insertion of a tracheostomy tube following tracheal transection (ISS = 16) and the other was intubated after a cardiac arrest secondary to myocardial contusion resulting from a kick from a horse (ISS = 16).

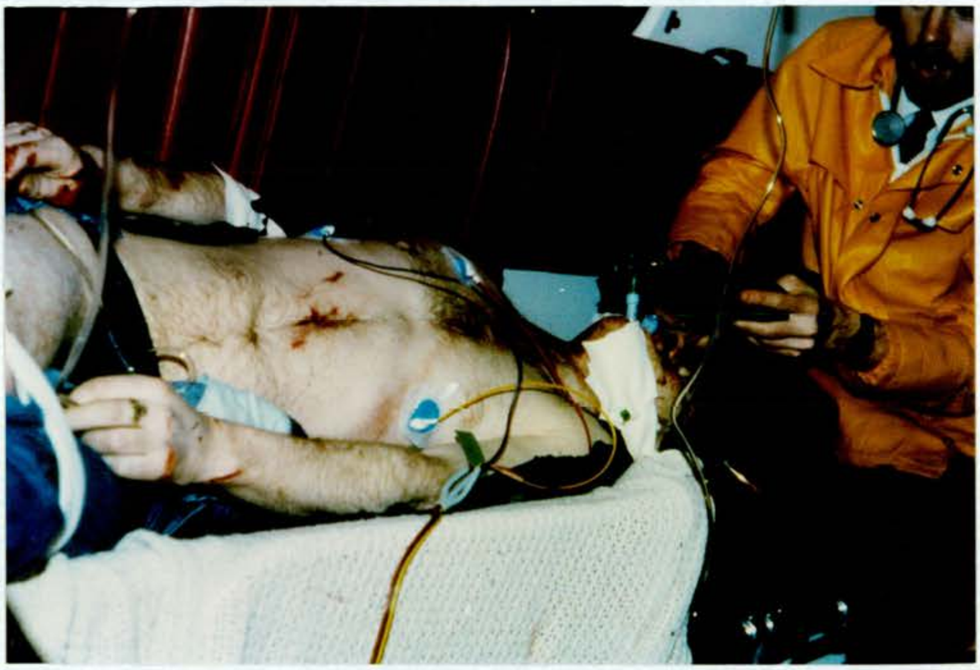

FIGURE 18 - Endotracheal intubation and ventilation.

Case 321. 28 year old man trapped for one hour following a road traffic accident.

		AIS	AIS^2
Head	Extensive subarachnoid haemorrhage	5	25
	L temporal and R occipital intracerebral haematomas	4	
Face	-		
Chest	Facture R 1-2 ribs	2	
	Fracture sternum	2	
	Extensive bilateral pulmonary contusions	4	16
Abdomen	Multiple tears both lobes of liver	5	25
	Contused R kidney	2	
Extremities	Dislocation R hip	3	
	Compound fracture R tibia	3	
External	Extensive forehead abrasions	1	
	Laceration R leg	2	

ISS = 66 (25+16+25)

5.3.3 Analgesia

Eighty-one patients (31.2%) received analgesia at the scene (Fig. 19). Forty-two patients required analgesia to assist with extrication or release from entrapment (median ISS = 13.5); 35 patients received intravenous opiate; 4 patients were given Entonox in addition to intravenous opiate; 2 patients received Entonox alone and one patient had a local anaesthetic ring block in addition to Entonox. The median ISS for patients who were trapped but not given analgesia during extrication was 29.5 and the difference in frequency distribution of Injury Severity Scores is signficant (Table 10).

When the head injury and associated conscious level of trapped patients was analysed, the distribution of Abbreviated Injury Scale ratings was signficantly lower in those that received analgesia compared to those that did not (Table 11).

Thirty-nine patients who did not require extrication received analgesia, median ISS = 11 (range 4-43); 36 patients received intravenous opiate; 2 patients received Entonox in addition to opiate and one patient had local anaesthetic infiltration.

FIGURE 19 - Analgesia

Case 337. 31 year old man trapped beneath a fork-lift truck. The patient received Cyclomorph and Entonox at the scene.

ISS cells	Analgesia	No analgesia
1-4	5	4
5-9	9	5
10-14	9	1
15-29	16	5
30 or >	3	15
TOTAL	42	30

$chi^2 = 19.97$, $df = 4$, $p < 0.001$

TABLE 10 - Frequency distribution of Injury Severity Scores in patients requiring extrication or release from entrapment.

AIS rating	Analgesia	No analgesia
0-1	24	6
2-3	12	7
4-5	5	16

$chi^2 = 16.30$, $df = 2$, $p < 0.001$

TABLE 11 - Frequency distribution of Abbreviated Injury scale ratings (Head) in patients requiring extrication or release from entrapment.

5.3.4 Chest drainage

Twelve patients (4.6%) had a chest drain inserted at the scene (Fig. 20) and in four of these the procedure was bilateral. The median ISS was 37 (range 9-57). The median AIS chest injury was 3.5. Seventy five per-cent of chest injuries were AIS $\geq$ 3. Four patients (33%) survived including a 17 year old male road traffic accident victim who had bilateral tension pneumothoraces relieved following rendezvous of the Flying Squad with the ambulance. In addition he received volume replacement during transfer and was found to have a ruptured spleen at laparotomy (ISS = 41).

Only one patient in retrospect did not benefit from chest drainage. He had sustained bilateral lower limb amputations and a Le Fort III facial fracture (ISS = 29). In addition to unilateral chest drainage, he was intubated and ventilated, a central and two peripheral venous lines were inserted and he received 5 litres of fluid during transfer to hospital. At post-mortem no pneumothorax or haemothorax was identified.

5.3.5 Medical anti-shock trousers

Medical anti-shock trousers were applied in 9 injured patients (Fig. 21). The median Injury Severity Score

FIGURE 20 - Chest drainage.

Case 142. 34 year old man who was involved in a road traffic accident. He was driving, not wearing his seatbelt and was trapped following the accident. He had fractures of R 5-7 ribs with an associated pneumothorax. A chest drain was inserted at the scene.

FIGURE 21 - Medical anti-shock trousers.

Case 342. 19 year old girl who fell 70 feet.

		AIS	AIS^2
Head	Compound left frontal fracture	3	
	Unconscious, no response to painful stimuli	5	25
Face	-		
Chest	Bilateral pulmonary contusions	4	16
Abdomen	-		
Extremities	Fracture left pubic ramus	2	4
External			

ISS = 45 (25+16+4)

was 25 (range 4-75). Three patients had sustained penetrating trauma (ISS = 4, 9 and 17) and in 6 patients MAST was applied following blunt trauma (median ISS = 44). Four patients had major abdominal injury (AIS 3, 5, 5 and 6), two of whom had severe thoracic injury in addition. Three patients had severe thoracic injury (ISS = 4, 4 and 6) but no associated abdominal injury. Two patients with no significant injury to the trunk had MAST applied; one patient was severely hypovolaemic from an arterial injury to the extremity (AIS 2) and one patient required stabilisation of a major pelvic fracture (AIS 3). Five patients subsequently died (median ISS = 45) and 4 patients survived (median ISS = 15.5). Of the 4 patients who survived 2 had sustained blunt trauma and 2 patients had sustained penetrating trauma.

5.3.6 Cardiopulmonary resuscitation

Cardiopulmonary resuscitation was instituted in 13 trauma patients with no detectable major pulses on arrival at the scene. There were 11 males (84.6%) and the mean age was 33 years (range 16-64). Ten patients (77%) had sustained blunt trauma with a median ISS of 50 (range 22-75). Three patients sustained penetrating wounds; one patient sustained a gunshot wound to the chest (ISS = 75); one patient received multiple stab wounds (ISS = 43) and a 21 year old male with a stab wound to the chest (ISS = 25) had an anterior thoracotomy at the scene and internal cardiac massage.

The mortality in patients who received CPR was 100%; 10 patients died at the scene, 3 patients died in the Accident and Emergency Department and one patient died 48 hours following admission.

In addition, CPR was carried out on a 15 year old boy who died from asphyxia secondary to crush injury of the chest when he was trapped beneath a stone slab; his injuries could not be adequately scored on the ISS system.

5.3.7 Treatment times

The hospital in-patient treatment times of survivors are summarised in Table 12 in which patients have been grouped by Injury Severity Score values. There is a positive relationship between ISS values and the length of hospital stay although there is a wide scatter as shown by the ranges. The treatment times do not include the periods of survival of 28 cases who died following admission from the Accident and Emergency Department. Patients who were transferred to another hospital were all followed up and their treatment times following transfer are included in the analysis.

ISS cell	No. of patients	Hospital stay (days) Range	Mean
0-4	38	1-17	2.9
5-9	53	1-97	8.9
10-14	31	1-164	20.7
15-24	39	3-210	22.7
25-34	14	5-111	37.5
35-50	16	16-360	118.9

TABLE 12 - Mean duration of hospital stay in relation to grouped ISS ratings.

5.4 Mortality

Of the 260 persons attended by the Flying Squad, 65 (25%) died. Of these 14 (21.5%) were dead on arrival at the scene. The time and place of death is given in Table 13. The median Injury Severity Score for all patients who died despite treatment by the Flying Squad (excluding one patient who died from crush asphyxia) was 45 (range 5-75). Fig. 22 shows the relationship between mortality and Injury Severity Score. Increasing ISS was associated with increasing mortality and the correlation was highly significant ($r = 0.99$, $p < 0.001$).

5.4.1 Abbreviated Injury Scale grading and mortality

In order to see whether this series of patients was similar to that from which the Injury Severity Score system was originally derived (Baker et al, 1974), the distribution of patient mortality by the AIS grade of the most severe injury was analysed. The distributions are seen to be very similar (Fig. 23). No statistical tests have been done on the mortalities of the first two grades which are virtually zero. For AIS grade 3, $chi^2 = 0.26$, $df = 1$, $p > 0.5$. For AIS grade 4, $chi^2 = 5.22$, $df = 1$, $p < 0.05$. For AIS grade 5, $chi^2 = 1.27$, $df = 1$, $p > 0.10$.

Time of Death	No. of patients	ISS range	Median
Dead when Flying Squad arrived	14	51-75	75
Died at the scene	11	22-75	50
Died within 3 hours of arrival in hospital	20	5-75	50
Died after 24 hours	19	9-66	33

TABLE 13 - Time and place of death.

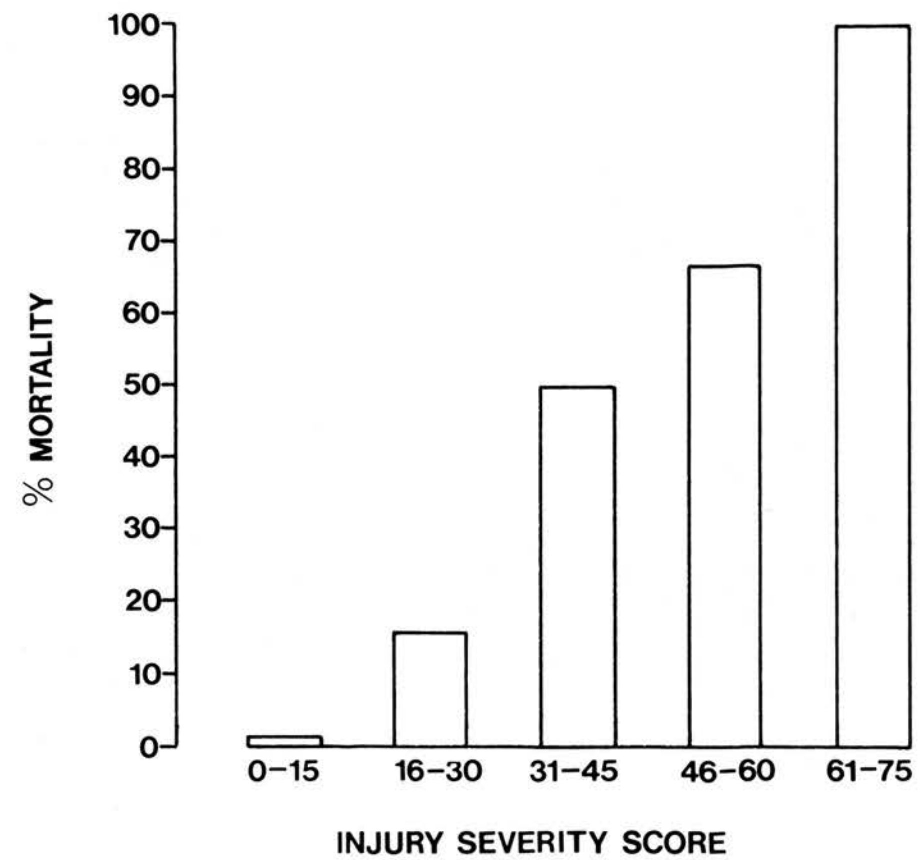

FIGURE 22 - Relation of mortality to grouped Injury Severity Scores.

The percentage of patients who died increased with the AIS grade of the most severe injury (Fig. 23). Patients in each of these 5 AIS severity groups had a wide spectrum of additional injuries. For instance, some patients whose most severe injury was grade 4 had no injury elsewhere, while others had minor to severe injuries to other parts of the body. As in Baker's original study mortality was found to increase in the presence of injury in a second body area (Fig. 24). For patients whose most severely injured area was grade 4, the death rate increased with injury severity of the second area, ranging from 25% in patients with no injury or grade 1, to 50% in those with a second grade 4 injury. Similarly for patients whose most severe injury was grade 5, death rates ranged from 30% to 80% depending upon the degree of injury in the second most severely injured area. Evidence for the non-linear relationship between the Abbreviated Injury Scale and mortality was also demonstrated; the death rates for patients whose most severe injury was grade 4, was higher than for others whose most severe injury was grade 5. In addition mortality for patients with 2 injuries each of grade 4, was not comparable to that of patients with 2 injuries of grade 5 and 3 (sum = 8 in both cases).

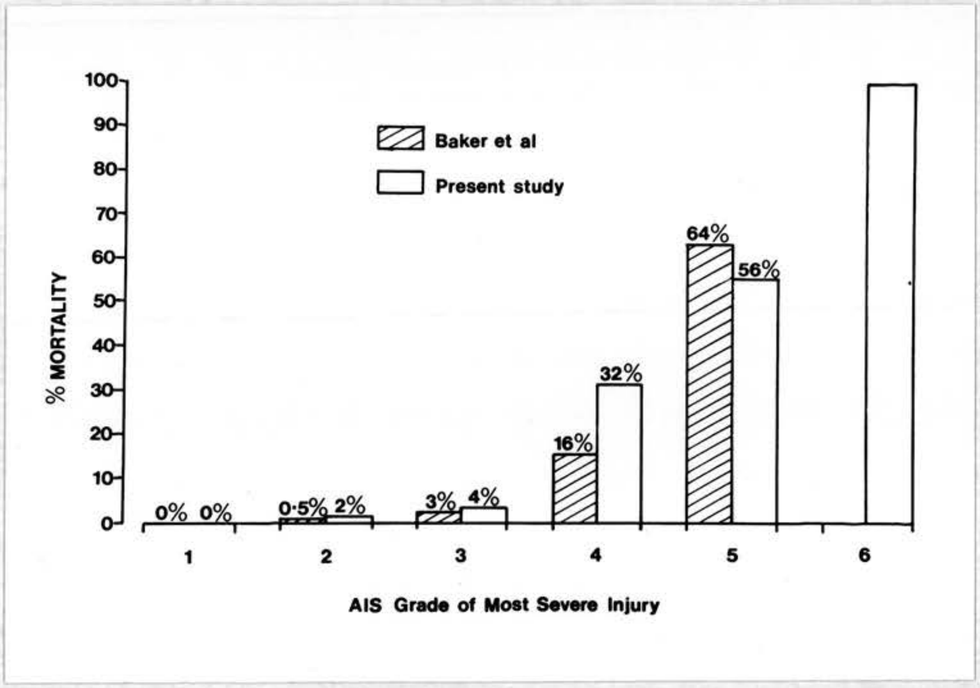

FIGURE 23 - Mortality by AIS grade of the most severe injury

Reproduced from Baker et al. (1974).

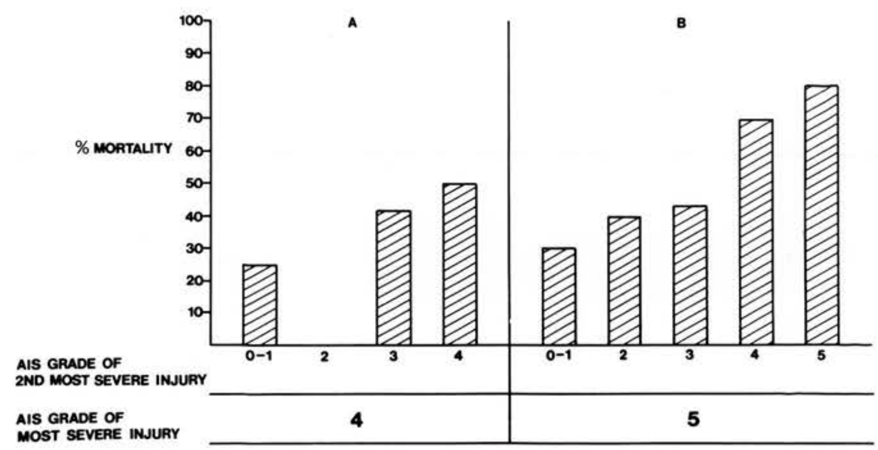

FIGURE 24 - Mortality by AIS grade of the second most severe injury: A, when the most severe injury was grade 4 and B, when the most severe injury was grade 5.

Reproduced from Baker et al. (1974).

5.4.2 Age effect on mortality

Fig. 25 shows the observed relationship between Injury Severity Score and mortality for 3 age groups. Death rates were higher for patients in the 45-64 age group than for younger patients and increased markedly for those aged 65 and over. The age associated increase in mortality was more pronounced for less severe injuries. For Injury Severity Scores of 20 or less, there were no deaths among patients less than 45 years. For Injury Severity Scores of 20-40 the death rates for patients aged 65 and over was more than 3 times the death rate for patients aged less than 45 years. For Injury Severity Scores of 50 and higher there was no age difference in mortality i.e. the highest score in a surviving patient was 50.

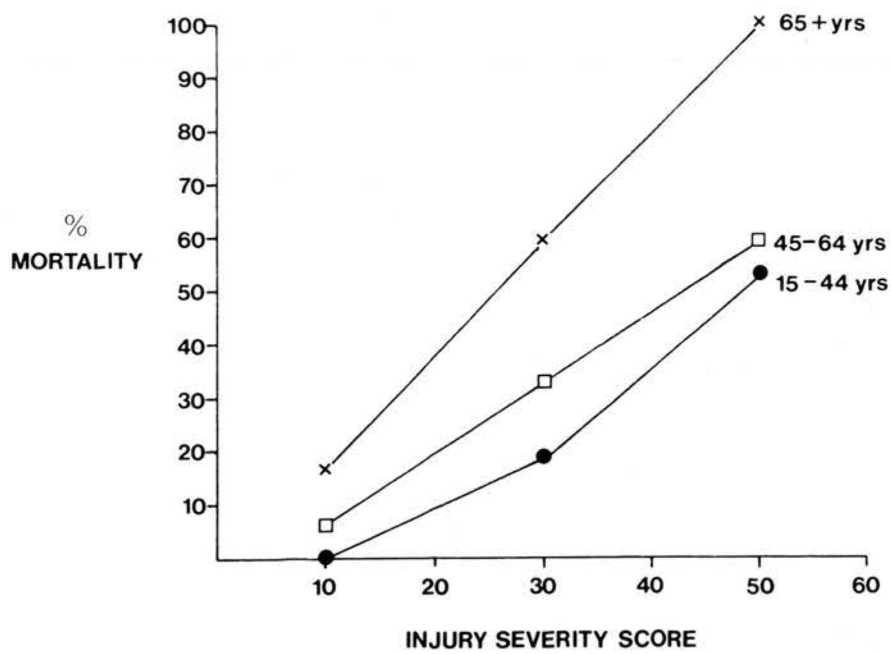

FIGURE 25 - Mortality by Injury Severity Score for three age groups.

5.4.3 Injury Severity Score to audit death

Table 14 shows the Injury Severity Score of patients who died despite receiving treatment from the Flying Squad. Although the median Injury Severity Score was noted to fluctuate the scores did not differ signficantly ($p > 0.5$). However the low median value for 1984 prompted further examination. Scrutiny of the post-mortem reports revealed 2 deaths with low Injury Severity Scores.

The first patient was a 55 year old woman who sustained a frontal skull fracture (AIS = 2) following a road traffic accident. She died on return to the Accident and Emergency Department, however the post-mortem report did not reveal any additional injury and death was attributed to an acute myocardial infarction. The second patient was a 75 year old man (ISS = 9) who had been stabbed in the abdomen injuring his spleen and pancreas. He died 8 weeks later from an acute myocardial infarction following peritonitis and septicaemia.

5.4.4 Prediction of survival and mortality

The mortality grid of Bull (1975) and the extended Probit lines described by Yates (1977) were used to

	Median ISS	ISS range
1981	50	27-75
1982	53.5	29-75
1983	45.5	25-66
1984	38	5-75
1985	43	26-59
1986	49.5	16-75

Wilcoxon rank sum, $p > 0.5$

TABLE 14 - Injury Severity Scores in patients who died (DOA's excluded)

provide an age corrected prediction of mortality and survival for the 259 patients in whom it was possible to ascribe an Injury Severity Score. The distribution of ISS is given in Fig. 26 and scores corrected to the 45-64 age group using the Probit lines (Fig. 2, page 38) is shown in Fig. 27. The Probit Analysis is not applicable to patients under 15 years and therefore 9 children who survived and 2 children who died have not had their scores corrected. In addition the 14 patients who were dead on arrival and received no treatment from the Flying Squad were excluded from the analysis. Applying the predicted chance of survival to the remaining 234 patients alive at the scene, 183.9 were expected to survive and 186 patients actually did survive (Fig. 28).

Using the mortality grid (Fig. 3, page 39), 54.7 patients were expected to die and 48 patients actually died (Fig. 29).

Using baseline chi-square analysis (Table 15) this difference was found to be significant. The highest chi-square increment fell within the ISS group 41-55.

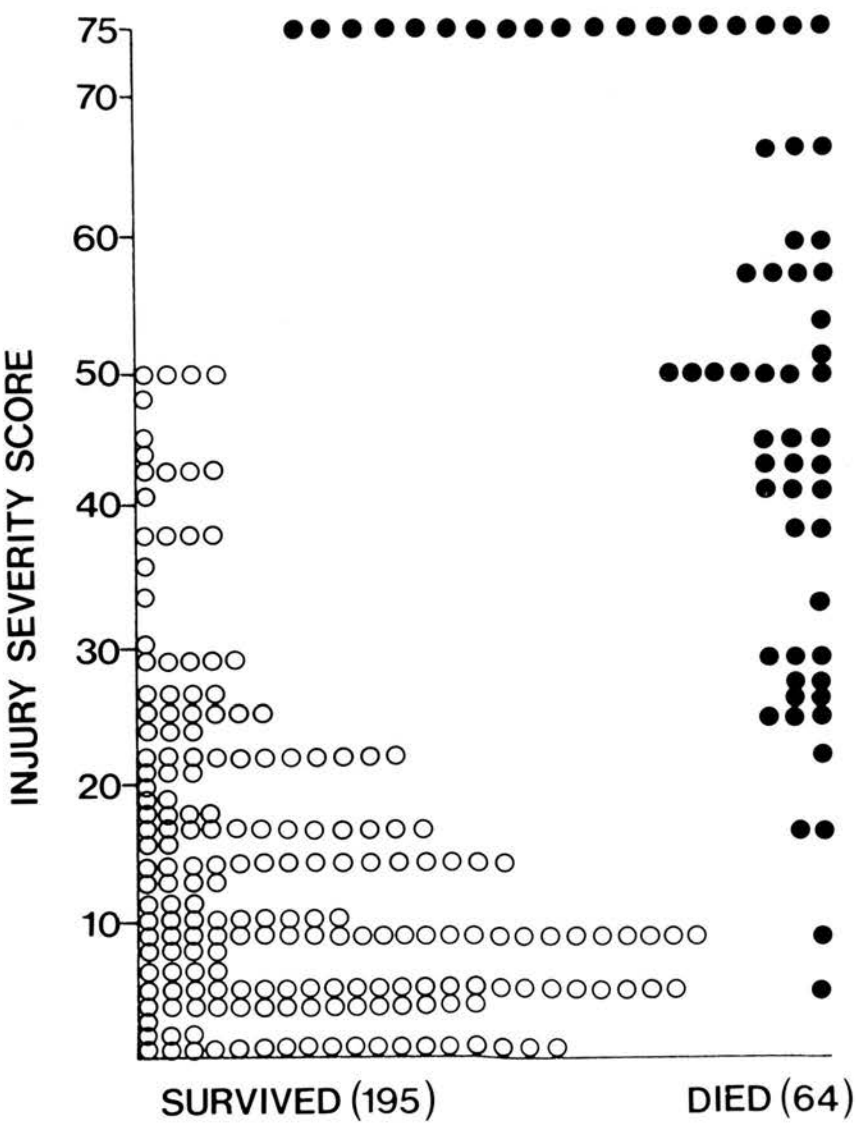

FIGURE 26 - Uncorrected Injury Severity Scores.

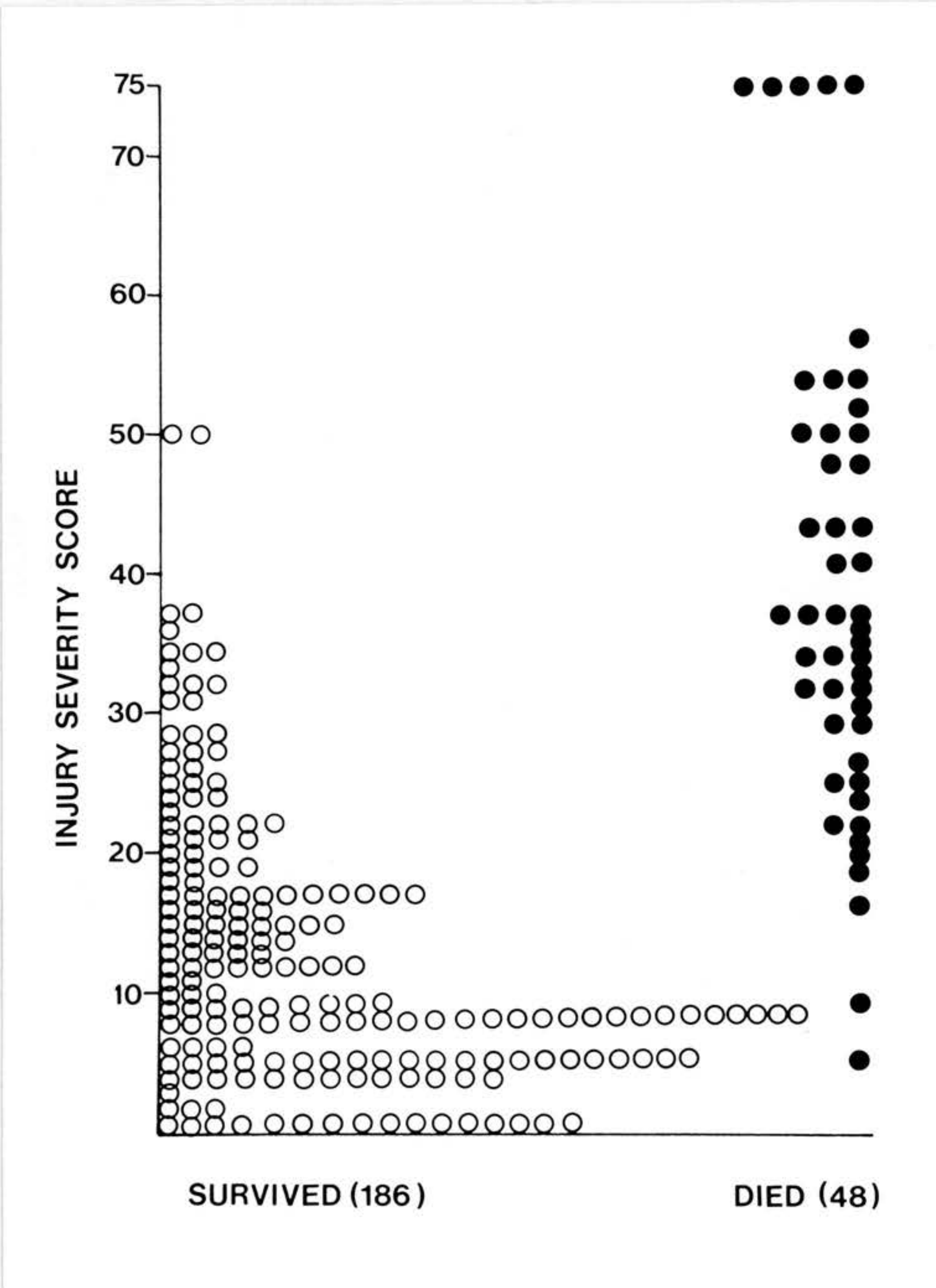

FIGURE 27 - Age corrected Injury Severity Scores.

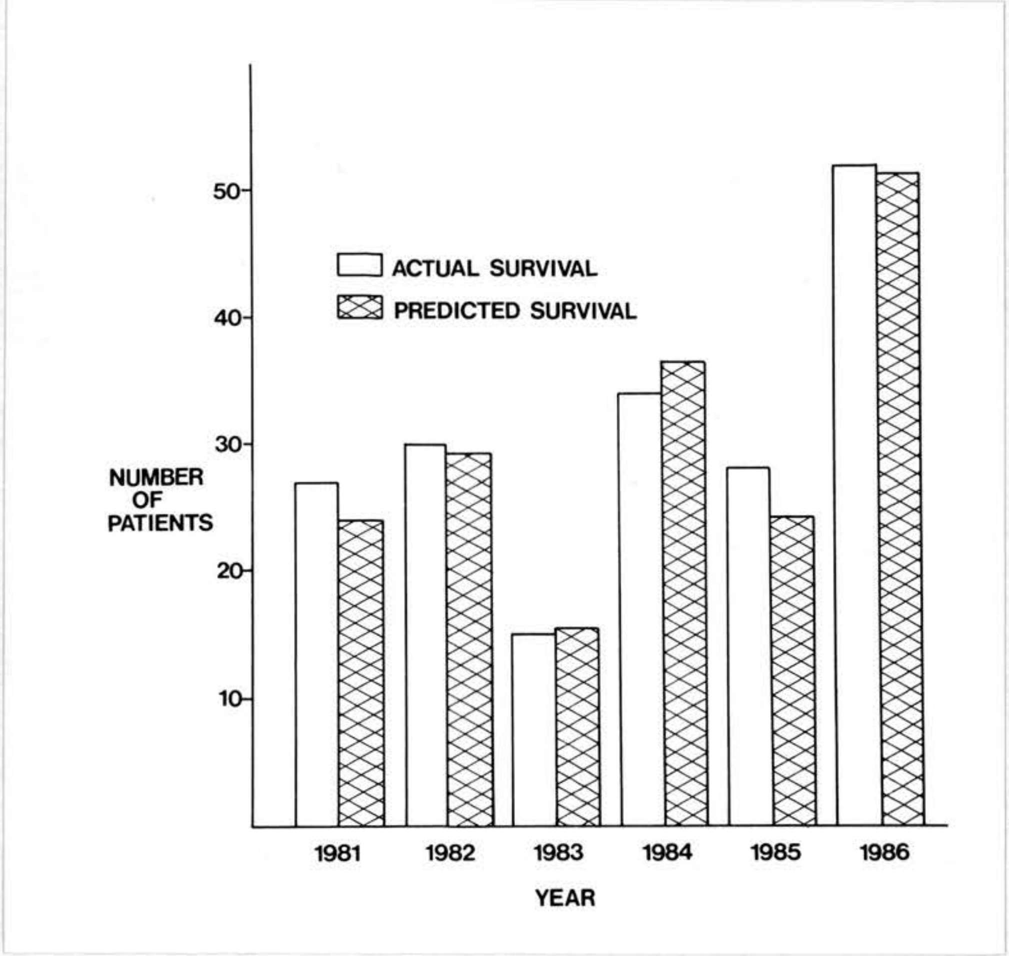

FIGURE 28 - Comparison of actual survival and survival predicted by the method described by Yates (1977).

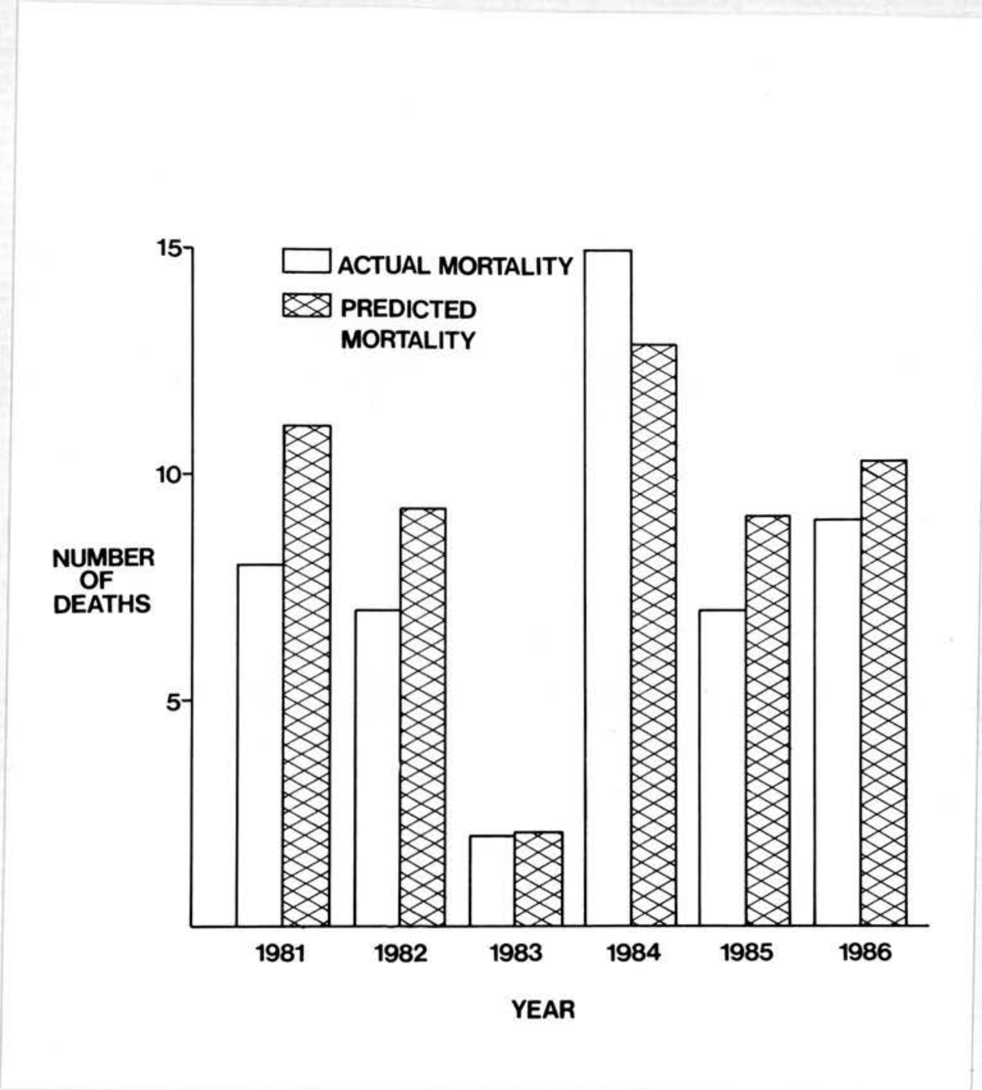

FIGURE 29 - Comparison of actual mortality and mortality predicted from Bull's (1978) table.

	INJURY SEVERITY SCORE			
	1-25	26-40	41-55	56-75
No. of patients	167	25	28	14
No. of deaths	8	10	16	14
Predicted per cent deaths	4.97	38.0	82.14	100
Chi-square increment	0.011	0.042	11.72	0

$chi^2 = 11.77$, $df = 4$, $p < 0.02$.

TABLE 15 - Baseline chi-square analysis.

5.5 Medical Call-outs

5.5.1 Out-of-hospital cardiac arrest

Attempts at cardiopulmonary resuscitation were made in 133 patients between 1981-1986. Criteria for inclusion in the analysis were patients with absent major pulses and loss of consciousness on arrival of the Flying Squad (Fig. 30). Patients in whom cardiac arrest was related to trauma were excluded in this analysis. Fig. 31 illustrates the increase in the use of the Flying Squad for such patients. One hundred and three patients (77%) were male and the mean age ($\pm$ SD) was 54.7 years ($\pm$ 18.2). Asystole was the presenting arrhythmia in 63 patients (47.4%) and ventricular fibrillation accounted for 44.4% (59 patients) with 11 patients (8.2%) having a bradyarrhythmia.

Fig. 32 illustrates the association between presenting arrhythmia and survival. The short term survival (those patients who survived to be admitted to a ward) was 22.6% (30 patients). The long term survival (those patients who left the hospital alive) was 8.3% (11 patients). Of the 11 long term survivors, 9 patients presented in ventricular fibrillation and 2 patients in a bradyarrhythmia.

FIGURE 30 - Cardiopulmonary resuscitation.

A 40 year old man collapsed on a stair landing. On arrival the electrocardiogram showed ventricular fibrillation. Following defibrillation he was intubated and ventilated and external cardiac massage performed using the "Thumper". Subclavian central venous cannulation was established as illustrated.

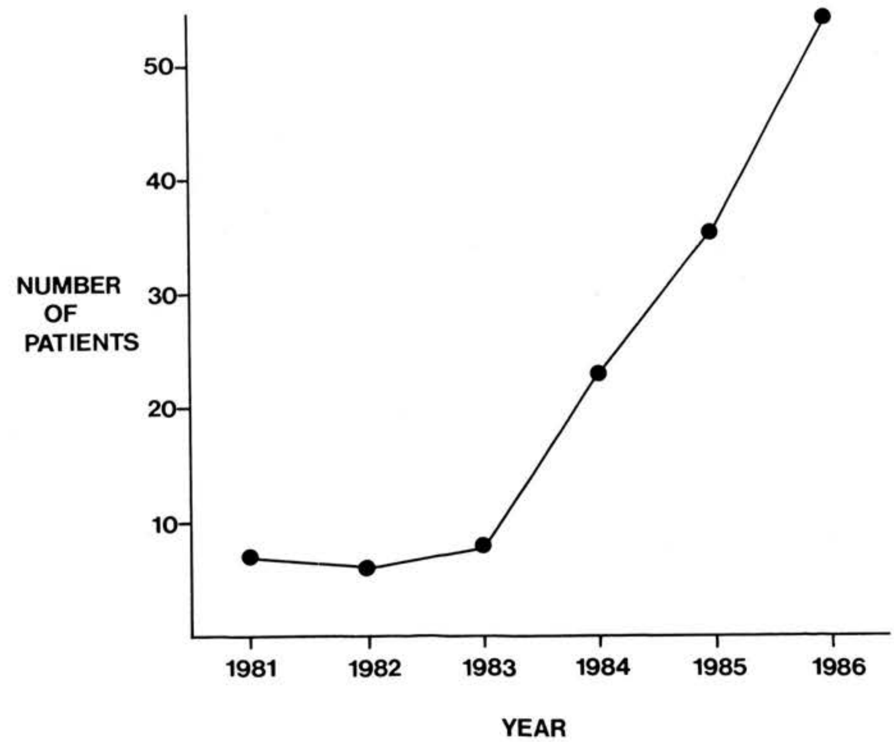

FIGURE 31 - Yearly distribution of cardiac arrest calls.

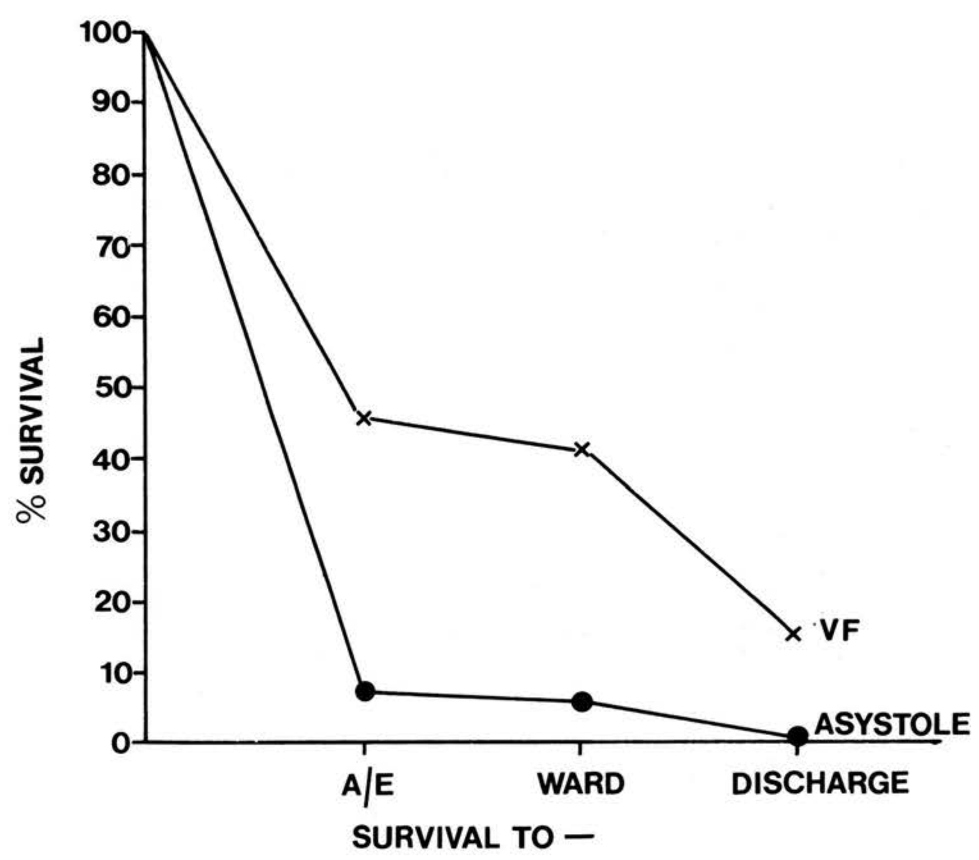

FIGURE 32 - Relation of primary arrhythmia to survival.

5.5.2 Medical emergencies

The Flying Squad attended 69 calls related to medical emergencies. On 7 occasions the Flying Squad assisted in transfer of a patient from another hospital. In these cases intravenous access, intubation and ventilation had been established prior to arrival of the team. Sixty-two patients therefore received treatment by the Flying Squad at the scene (Table 16). Forty-three patients (69%) survived to discharge from hospital, 6 of whom required endotracheal intubation and assisted ventilation.

Diagnosis	Number of Patients	Intravenous access	Endotracheal Intubation/ Ventilation	IV, IM or E.T. Drug administration	Survival
Myocardial infarction	15	15	2	10	9
Cardiac failure	4	4	1	4	3
Acute severe asthma	5	1	1	5	5
Respiratory obstruction/arrest	5	5	5	2	2
Cerebrovascular accident	6	4	2	3	2
Overdose	4	4	2	1	3
Anaphylactic reaction	4	3	-	2	4
Status epilepticus	3	3	-	-	1
Gastrointestinal haemorrhage	2	2	-	2	3
Hypoglycaemic coma	3	2	-	2	3
Miscellaneous	11	8	1	4	8
Total	62	51 (82%)	14 (23%)	36 (58%)	43 (69%)

TABLE 16 - Medical emergencies

CHAPTER 6

DISCUSSION

6.1 Profile

There has been an increasing demand for the service provided by the Edinburgh Flying Squad during the period of this study; the frequency of calls rising from an average of one per week during the first year of the squad's operation to 3 per week in 1986. This has in part been related to increasing awareness by the Emergency services of the function of the squad and has also been reflected in the decreasing proportion of "aborted" calls. Similar patterns of increasing demand on such squads following their inception have been reported by other workers (Collins, 1966; Brett, 1980). In addition, although Accident Flying Squads were originally intended to treat trauma patients, a considerable and increasing proportion of their workload is of "medical" cases (Rowley & Collins, 1979; Harrop & Bodiwala, 1983; Robertson & Steedman, 1985). The reverse situation has been noted in North American centres where advanced life support in the pre-hospital setting is performed by paramedic personnel. Originally these Emergency Medical Systems were set up to treat cardiac cases but now have extended their scope of practice to deal with trauma patients (Luterman et al., 1983; Smith & Bodai, 1985).

Clearly any increase in workload associated with the development of Accident Flying Squads should not result in any compromise to the service provided by the base department. Appropriate staffing is therefore necessary to provide adequate cover and accordingly most schemes operate from large, usually teaching hospital Accident and Emergency departments (Bodiwala, 1982).

The mean duration of call-out in this study was just under 45 minutes with 85% of calls lasting less than one hour. Snook (1972a) reporting on the Bath Accident Flying Squad noted that the average time to answer calls and to subsequently clean and maintain equipment was 65 minutes per week. The efficiency of the department was therefore not significantly affected. Any decrease in efficiency that may occur is more than balanced by the initial resuscitation performed prior to the patient's arrival in the Accident and Emergency department (Little, 1976). One report (Anonymous, 1979) suggesting that calls do not often disrupt other work because they come at night or out of normal working hours was not substantiated in this study. Both medical and trauma calls peaked during the day and this pattern is similar to that found by Snook (1972a).

Essential to the operation of any Flying Squad is the ability to respond rapidly to a call-out. To facilitate such a rapid response all members of the team must be immediately available. Ideally team members including senior medical staff should be provided from the Accident and Emergency department thereby avoiding the delay encountered in some schemes when staff from other departments such as anaesthetics are involved (Collins, 1966). In the present study an acceptable response time of just under 4 minutes from the receipt of call to "on-road" mobilisation was recorded and was comparable to that found for the Derby Flying Squad, (Little, 1972).

One of the major concepts underlying Accident Flying Squads is the potential to decrease the time taken for patients to receive skilled medical care either when the transfer is delayed, or is prolonged. Delay may arise when the patient is trapped or impaled and prolonged transfer may occur when the accident scene is at a considerable distance from the receiving hospital.
More than three-quarters of calls were located within the city boundary and although transfer times would therefore have been short, assistance was usually required because of delay in evacuating the patient.
The median Injury Severity Score was higher for patients in calls outwith the city boundary. This may reflect a tendency for ambulance crews to call the Flying Squad to assist in the transfer of more seriously injured

patients from a rural accident scene even though these patients may not have initially been trapped. There may also have been more readiness on behalf of ambulance personnel to summon the squad to trapped patients irrespective of the severity of injury when the accident occurred in an urban area because of the short response time.

The Edinburgh Flying Squad forms an integral part of the major incident plan for the Lothian and Borders area providing the site medical team. The involvement of mobile medical teams in major accident planning has previously been criticised on grounds of complicated response arrangements, inexperienced team members, insufficient and inappropriate equipment and inadequate provision of clothing for members of the team, (Finch & Nancekievill, 1975). Emphasis has subsequently been placed on the need to build major accident plans around facilities used for every day accident work (Anonymous, 1979). The pre-hospital care system described in this study provides a well rehearsed and experienced team using a comprehensive range of equipment with which they are familiar. The squad responded rapidly to 17 airport alerts during the study period although all calls were aborted en route.

The Flying Squad attended more than one patient at the scene in approximately one fifth of trauma calls. A much larger vehicle would be required to accommodate all the resuscitative equipment presently carried by the squad in addition to providing the facility to transport patients. No difficulty was encountered with the present system where equipment could be easily transferred in light-weight cases to the ambulance already present at the scene and sufficient equipment and staff were available to facilitate transfer in a second ambulance should this have been required.

6.2 Trauma Patients

6.2.1 Injury Severity Scores

Major trauma has been defined for the purposes of previous studies as an Injury Severity Score of 15 of more (Lowe et al., 1983; O'Byrne & Bodiwala, 1987). However, as it is impossible to derive a score of 15 using the ISS system it would seem more appropriate to use a score of 16 or greater (Long et al., 1986). The median Injury Severity Score for patients treated by the Edinburgh Flying Squad was 16 and therefore just over half the total number of trauma patients had major trauma. Few problems were encountered in using the Injury Severity Scoring System. The scores seemed to reflect accurately the clinical impression of severity with the exception of some penetrating injuries; the median ISS in the present study was 5 compared to 17 for blunt trauma. Since the system was developed from studying injuries sustained by road traffic accident victims, this apparent drawback in regard to penetrating injuries is probably not surprising and has been remarked upon by other workers (Baker et al., 1974; Stoner et al., 1977; Christian, 1986). Semmlow & Cone (1976) in their study of 8,852 patients from the Illinois Trauma Registry (62% of whom were not injured in road accidents) held that the ISS could appropriately be applied to all types of trauma irrespective of the mechanism although in their series only 4% of 5,502 patients not injured in road traffic accidents had an ISS greater than 20 compared with 20% of 3,350 victims of road traffic accidents. In the present study the median Injury Severity Score for vehicular occupants involved in road traffic accidents was the same (ISS = 17) as that for patients injured from other mechanisms of blunt trauma, although 8 pedestrians (median ISS = 20) and 6 motor cyclists (median ISS = 24) were included in the latter group of 70 patients. In addition, the distribution of Abbreviated Injury Severity Scale ratings within 6 body regions did not differ significantly between vehicular occupants and non-vehicular occupants injured as a result of blunt trauma except in relation to head injury when severity was greater in the latter group.

One further type of trauma in which difficulty was encountered in assigning an Injury Severity Score was that in relation to injury resulting in asphyxiation. In this study the only patient in whom it was impossible to derive a score had sustained such an injury and similar problems have been found in previous studies (Gorman & Coals, 1983).

Although most North American centres quote mean ISS values when reporting on patients treated by their advanced pre-hospital life support systems, these average scores are higher than the median ISS for the Edinburgh Flying Squad; in one study from Boston a mean ISS of 22.9 was found (Jacobs et al., 1984). On arrival at the scene the Flying Squad team will attend all injured patients for which the squad was originally summoned, thus lowering the median Injury Severity Score for the population.

6.2.2. Falls from a height

In a study comparing Injury Severity Score with plasma cortisol concentration, Stoner et al. (1977) confirmed that the method could distinguish between minor and moderate injuries and noted that the ISS values seemed to be related to the amount of force need to cause the injuries. Baker and co-workers (1974) suggested that the transfer of mechanical energy occurring as a result of a fall from a height may be similar to that sustained in a road traffic accident and therefore may be similarly scored using the ISS. However to date, there has been no previous report on the relationship between Injury Severity Score and blunt trauma sustained as a result of a free-fall. The present study documented a significant relationship in 28 patients with such trauma. In a review of 108 patients who jumped or fell 50 metres from Seattle's Aurora Bridge over a period of 49 years, the average ISS of those who died from water impact was 40 compared with 70 for those who died from ground impact (Fortner et al., 1983). The mean ISS of 4 patients who survived prior to the introduction of an emergency pre-hospital medical care programme was 12 and following its introduction the mean ISS for 22 survivors was 25. In comparison, the mean ISS value for patients treated by the Edinburgh Flying Squad was 16 for survivors and 38 for those patients who died. The Seattle group attributed the improved survival to on site resuscitation and claimed that their "Medic I" programme was superior to their previous "Load and go" policy.

6.2.3 Penetrating trauma

The role of advanced trauma life support in the pre-hospital care of patients injured from penetrating wounds remains controversial (Trunkey, 1984). While some workers advocate minimal or no intervention at the scene (Gervin & Fischer, 1982; Border et al., 1983; Smith et al., 1985; Smith & Bodai, 1985) others state that airway care and intravenous fluid resuscitation are life saving (Copass et al., 1984; Jacobs et al., 1984; Pons et al., 1985). Seven per-cent of trauma patients (18) treated by the Edinburgh Flying Squad sustained penetrating injuries of whom 7 sustained penetrating wounds to the thorax or abdomen. This proportion is considerably less than populations of trauma patients treated by emergency pre-hospital systems in North America where penetrating trauma may account for 18% of those patients treated (Mattox et al., 1986). Pons et al. (1985) reviewed 203 patients with penetrating wounds to the thorax and abdomen who received advanced life support at the scene. The average time required for ambulance response to the scene was approximately 4.5 minutes. Time spent at the scene averaged 10 minutes and the transfer time to hospital averaged 6 minutes. Measures taken at the scene included the establishment of intravenous lines (1.8 per patient), application of a pneumatic anti-shock garment (81 patients) and 28 patients underwent endotracheal intubation. Thirty-three patients had no blood pressure at the scene, 6 of whom survived (18%). One hundred and sixty of the remaining 170 patients who had initial blood pressure survived. In conclusion they stated that advanced life support can improve the haemodynamic status of the patients at the scene or during transfer and supported the role of paramedic intervention in patients with penetrating trauma. Gervin & Fischer (1982) reported a retrospective study of 23 patients with penetrating heart wounds and compared the outcome of those in whom prolonged attempts at stabilisation were made at the scene. The survival rate for those patients who received minimal in-field treatment and in whom transfer times averaged 9 minutes was 83%. In contrast no patient survived in whom stabilisation was attempted at the scene (mean transfer time 25 minutes). All patients had been injured within 10 minutes transfer time from hospital. Their data therefore suggested that prompt transfer without attempts at field resuscitation provided a better chance of survival in patients with penetrating heart wounds.

Should Accident Flying Squads be called to patients with penetrating trauma? There is clearly an inherent delay in mobilising the Flying Squad with an assessment of the patient and the situation initially being made by the ambulance crews prior to summoning the team. The response times quoted from Denver (Pons et al., 1985) cannot therefore be matched and on that basis a course of action suggested by Gervin & Fischer (1982), of prompt transfer with appropriate airway care only is recommended. Only when there is a delay in transfer as a result of impalement would the services of a Flying Squad be of benefit.

6.3 Treatment of Flying Squad patients

6.3.1 Intravenous fluid replacement

Retrospective reviews of trauma patient deaths postulate that approximately 20% of such deaths occur unnecessarily in the pre-hospital setting (Frey et al., 1969; Lowe et al., 1983) and many of those are from exsanguination (Gilroy, 1985). A threefold increase in mortality has been reported for every 30 minutes which elapse without medical care (Cowley et al., 1973). However the pre-hospital care provided for the hypovalaemic patient is resuscitative and supportive but not definitive (Trunkey, 1982). Therefore delay caused by establishing an intravenous line in the field may not be in the patient's best interest (Border et al., 1983).

Smith et al., (1985) reviewed 52 consecutive cases in which pre-hospital stabilisation was attempted prior to transfer. In all cases the time to establish intravenous access was longer than the transport time. In addition, paramedics failed to place a line in 28%; this occurred more frequently in the severely injured patient. The average time for a paramedic to establish an intravenous line is 10-12 minutes, (McSwain et al., 1980; Smith et al., 1985). This 10 minute delay may result in loss of 2000-3000 ml of blood in a patient who will arrest from haemorrhage and paramedics can rarely replace more than 1000-2000 mls in the same time period (Border et al., 1983). According to Aprahamian (Border et al., 1983), taking 12 minutes to start an intravenous line is a measure of incompetence. Although this may be true given the ideal conditions of a hospital setting, it has been stressed that "it is quite another thing to crawl into a mangled automobile at night, amid hysterical bystanders and impatient police officers and start an IV on a patient behind the steering wheel" (Caroline, 1977). Smith et al. (1985) conceded that in patients with transportation times in excess of 30 minutes intravenous fluid resuscitation may be of benefit and Trunkey (1984) affirmed that in a protracted extrication an intravenous line should be established.

In a comparative study of 178 patients receiving advanced versus basic life support, Jacobs et al. (1984) concluded that appropriate field ALS resuscitation results in more favourable outcomes following major trauma and in their study the average intravenous crystalloid fluid administration was 700 mls. The value of such a replacement volume has been contested by Trunkey (1984), pointing out that only one third of this volume remained in the vascular space. In a review of the paramedic system in Seattle, the volume of intravenous infusion in patients who survived was 900-3700 mls (Copass et al., 1984) and seemed to answer the concerns of Border and co-workers (1983), that in an urban setting the transportation time is too short to allow adequate fluid administration to counteract the effect of severe haemorrhage.

In the United Kingdom there are those that are strongly in favour of extended ambulance skills including blood volume replacement in the field (Baskett & Sleet, 1987). The Scottish Early Emergency Care Group, reporting on the potential and benefits of advanced pre-hospital care, pointed out that previous studies had ignored the possibility that many patients apparently successfully treated by advanced techniques may also have survived had only standard basic methods alone been employed (Anderson et al., 1987). Of the 26,358 patients studied, it was claimed that only one trauma patient with hypovolaemia may have benefited from blood volume replacement. Gorman & Coals (1983), reporting on 250 patients treated by the Derby Flying Squad, claimed that 6 hypovolaemic patients undoubtedly had their lives saved by the rapid administration of intravenous fluids and a further 11 patients had their chance of survival improved. However these statements were made on purely subjective clinical grounds.

The patients treated by the Edinburgh Flying Squad who received less than 500 mls (median ISS 13) probably did not derive any benefit from their volume replacement. However the time to establish an intravenous line at the scene can be offset against the time it would have taken to carry out the procedure in the resuscitation room. In addition blood can be withdrawn at the same time for cross matching and if the patient is trapped the specimen can be taken to the laboratory in advance by the police. Fifteen per-cent of patients treated with bood volume replacement by the Edinburgh Flying Squad received in excess of 1500 mls in the field. This was more than twice the average volume that was reported by Jacobs and co-workers (1984) and criticised on the grounds of inadequacy by Trunkey (1984). Twelve per-cent of patients received in excess of 2000 mls, compatible with favourable outcomes reported by the Seattle group (Copass et al., 1984) and with other Flying Squads (Little, 1976). The times quoted by workers in the United States for paramedics to establish a peripheral intravenous line may well be longer than that taken by members of the Flying Squad team although similar difficult circumstances to that described by Caroline (1977) were encountered.

In summary, patients injured within an urban environment with short transfer times to hospital do not warrant Flying Squad intervention. However patients requiring prolonged extrication would probably benefit from medical expertise at the scene to establish both peripheral and central intravenous lines and subsequent blood volume replacement. Likewise, patients injured in a rural environment with prolonged transport times would benefit from rendezvous with the Flying Squad.

6.3.2 Airway Care

It has been estimated that head injuries and airway obstruction account for 60-70% of all pre-hospital deaths (Trunkey, 1984) and that 10% of these may be preventable (Hoffman, 1976). Jennett and colleagues (Rose et al., 1977; Jennett & Carlin, 1978) have drawn attention to avoidable factors contributing to death after head injury. One such factor, commonly seen in patients admitted to neurosurgical centres, is respiratory difficulty leading to hypoxia (Miller et al., 1978); Jeffreys & Jones, 1981). In a study of 150 comatose patients transferred to one neurosurgical unit after head injury, only 28% were intubated; untoward incidents which could have caused secondary brain damage occurred in 61 patients and the commonest mishap was airway obstruction (Gentleman & Jennett, 1981). A low incidence of systemic insults including hypoxia were reported from California where all head injuries are primarily routed to a small number of neuro surgical units; 91% of patients had an endotracheal tube inserted at the scene by paramedics (Marshall et al., 1979). MacDonald et al. (1981) have highlighted the difficulty in maintaining an adequate airway during transport of a patient from the accident scene by ambulance and the difficulty in assessing and maintaining inspired oxygen and ventilatory requirements under these circumstances has been reported by Waddell et al. (1975). A comparison of the characteristics of surviving patients and non-survivors treated by Seattle paramedics was made by Copass and workers (1984), who noted that 97% of surviving patients (mean ISS = 32) had been intubated at the scene compared to only 65% of non-survivors (ISS = 28). However, although there was no statistical difference between Injury Severity Scores, 60% of surviving patients had sustained penetrating trauma whereas 95% of non-survivors had blunt injuries. Fortner et al. (1983) claimed that overall survival in patients injured as a result of falling 50 metres from Seattle's Aurora Bridge was tripled following the introduction of an advanced life support programme in which 55% of patients were intubated at the scene. Some workers still however advocate a "scoop and run" policy for urban trauma with minimal or no intervention in the field (Gervin & Fischer, 1982; Smith et al., 1985) and in a recent review of advanced life support procedures, Gold (1987) highlighted the lack of evidence to support the use of endotracheal intubation or the use of an oesophageal airway in offering significant improvement in survival. He suggested that further analysis might conceivably reveal that both techniques are unreasonable in certain situations in which a lesser procedure would be more appropriate. In support of this, the Scottish Early Emergency Care Study Group claimed that only one patient out of 50 non-surviving trauma cases would have had their probability of survival improved in the long term from endotracheal intubation (Anderson et al., 1987).

Fifteen per-cent (39 cases) of injured patients treated by the Edinburgh Accident Flying Squad had an endotracheal tube inserted at the scene and 10 of these patients survived. Only 2 patients in a review of 179 injured patients treated by the Derby Flying Squad were intubated despite a comment that 20 patients were unconscious at the scene (Gorman & Coals, 1983). Similarly, intubation was only attempted in 6 out of 116 accident victims treated by the Leicester Flying Squad and in only 4 of these was the procedure successful (Harrop & Bodiwala, 1983). This probably relates to the very junior nature of the medical team comprising this squad. In a prospective review of 187 endotracheal intubations by paramedics, Jacobs et al. (1983) reported a 96.6% success rate with no associated complications. In analysing their failures they drew attention to several situations in which intubation may be difficult to perform in the field including copious vomiting and major facial trauma. However these are the very patients who require such definitive airway care which perhaps could be achieved by senior members of an Accident Flying Squad.

The evidence would therefore suggest that if endotracheal intubation can be performed by someone experienced in the procedure including the expertise to intubate in difficult circumstances at the scene or during transfer, then such definitive airway care would be of benefit to patients with severe head injuries or those with airway compromise. Such expertise can be provided by Accident Flying Squad teams and should be directed to trapped patients where delay is inevitable or after rendezvous when intubation may prevent secondary systemic insult during a prolonged transfer.

6.3.3 Analgesia

The pain caused by the extrication of a patient from a vehicle or during transfer to hospital may result in deterioration of the patient's condition with associated increase in morbidity and mortality (Baskett & Withnell, 1970; Waddell et al., 1975; Hines, 1985). Entonox remains the most widely used pre-hospital analgesia in the United Kingdom and is used by virtually all Health Authority Ambulance Services (Hines, 1985). Some workers have found that pain may be satisfactorily controlled by Entonox and that opiate analgesic is rarely necessary (Baskett & Withnell, 1970; Snook, 1972a). However, in some circumstances Entonox may be ineffective and an intravenous narcotic analgesic may be required (Hines, 1985). The problems of regulating the administration of opioids by paramedics in the United States has been highlighted by Smith & Bodai (1985). However in the United Kingdom intravenous opioids are regularly used by either General Practitioner Accident Services (Silverston & Silverston, 1985) or Accident Flying Squad Teams (Little, 1972; Harrop & Bodiwala, 1983). The use of intravenous opioids in the pre-hospital setting has been criticised by Snook (1969a) because of interference with the signs of head injury, the diagnosis of abdominal trauma, respiratory and cardiovascular depression. Intravenous opioids were used regularly by the Edinburgh Flying Squad to supplement Entonox although criticism could be levelled at the Squad for administrating such analgesia to a number of patients with serious head injury as graded by the Abbreviated Injury Scale. However, intravenous Morphine was used successfully in the Falklands campaign and when administered in small aliquots and titrated against response it is considered safe (Williams et al., 1983). This has been echoed in civilian pre- hospital practice and Naloxone can always be used to reverse any untoward effects (Little, 1981b).

6.3.4. Chest drainage

In an autopsy study of 374 road traffic accident victims dying within 12 hours of injury, Ruffell Smith (1970) reported that 34% of deaths were due entirely to chest injury. After reviewing 144 deaths from road traffic accidents occurring before arrival in hospital, Gilroy (1985) commented that two thirds of deaths due to chest injury may have responded to early medical care if it had been available within a very short time of the accident. The detrimental effect of untreated chest injury in the presence of head injury was highlighted by Jeffrey & Jones (1981) who reported that in 103 head injured patients with avoidable factors contributing to death, 14% had thoracic injury. However the difficulty in diagnosis when patients present with such a combination of injuries was pointed out by Irving & Irving (1967) when only 2 out of 9 pneumothoraces were identified early in the course of the patient's management.

Chest drainage in the field is not a procedure commonly carried out by paramedics in the United States (Jacobs & Berrizbeitia, 1984). Silverston & Silverston (1985), reporting on 1,329 patients treated by the Mid Anglia General Practitioner Accident Service (MAGPAS), commented on only 2 cases requiring chest drainage. In a review of 20,358 patients transported as emergency cases to two Accident and Emergency Departments, Anderson et al. (1987) considered that chest drainage could have been used by advanced trained ambulancemen, however allowing for the maximal possible benefit in terms of patient survival, they suggested that no benefit would have accrued. On the other hand, Kreis et al. (1986) highlighted 52 preventable non-CNS deaths in Dade county, Florida, amongst 1,201 trauma deaths in 1982, in which earlier insertion of a chest drain may have been life saving in 3 patients. Likewise, Gorman & Coals (1983) delineated 44 patients who were alive at the scene when their Flying Squad arrived but who subsequently died. Scrutiny of the records revealed 4 cases in whom they considered that earlier insertion of a chest drain might have led to survival (ISS = 34, 41, 51, 54). The median ISS in 12 patients treated by the Edinburgh Flying Squad Team who underwent chest drainage was 37 and in 75% the chest injury was serious (AIS $\geqslant$ 3). Four patients subsequently survived including one patient who had bilateral tension pneumothoraces. Seven patients treated by the Leicester Flying Squad had a chest drain inserted at the scene (Harrop & Bodiwala, 1983). Of the 2 patients who survived, neither had a chest injury confirmed in hospital. In conclusion there are a number of patients with thoracic injury in whom earlier insertion of a chest drain would be life saving, particularly when a delay arises in patient transport to hospital. Similarly, "prophylactic" chest drainage in patients requiring intermittent positive pressure ventilation during transfer may avoid potential complications from their thoracic injury. However, if such a procedure is to be carried out in the pre-hospital setting the decision to do so must be made by a doctor with considerable experience. This study would indicate that a Flying Squad Team led by senior medical personnel could provide such care.

6.3.5 Medical anti-shock trousers

The current role of pneumatic anti-shock garments remains controversial (Bodai et al., 1987). Many authors in the United States have concluded that MAST are safe and effective in the pre-hospital stabilisation and management of trauma patients (Pelligra & Sandberg, 1979; Wayne & McDonald, 1983; Kaback et al., 1984) and are currently advocated by the American College of Surgeons Committee on Trauma (1981) as an adjunct in the manage of haemorrhagic shock. Although conceptually attractive as a mechanism to "provide limited auto-transfusion", "to elevate blood pressure" and to "save lives", there has been until recently no randomised prospective evaluations in humans to substantiate such widespread use (Civetta et al., 1976; McSwain, 1977; MacKersie et al., 1984). Such an evaluation was first carried out by Mattox et al.

(1986), who randomised 352 patients with pre-hospital systolic blood pressures of less than 90 mm Hg to receive treatment with MAST (163 patients) and no MAST (189 patients). Age, mechanism of injury (88% penetrating trauma), pre-hospital fluid administration, Injury Severity Scores (mean ISS = 19.8 MAST and 21.0 no MAST), operative protocol and calculated probability of survival were virtually identical for both groups. The predominantly injured area was the abdomen in 40%, the thorax in 37% and the extremities in 13% of patients. There was no statistically significant difference in evaluation and outcome between the groups. They concluded that for penetrating trauma with pre-hospital times of 30 minutes or less, MAST provides no advantage with regard to survival. Clearly further prospective randomised evaluations of medical anti-shock trousers in blunt trauma are required. Because of the lack of controlled trials and controversy surrounding the use of MAST, Bodai et al. (1987) have recommended abandoning its use in the urban pre-hospital setting. They considered that the selected use of MAST may be reserved for patients needing longer transport times (greater than 20-30 minutes). Prolonged transport times and delay in extrication are the very situations to which the Flying Squad may be called.

The median ISS for patients who had MAST applied by the Edinburgh Flying Squad was 25. In the case of blunt trauma the median ISS was 44 indicating their restriction in use for severely multiply injured patients. Two patients with penetrating injury with relatively low ISS (4 and 9) had MAST suit applied. However, they were both severely hypovolaemic and in addition received greater than 4000 mls volume replacement during transfer. Four patients (median ISS = 15.5) who survived had MAST applied and although it is difficult to attribute this directly to MAST suit application, selected use of pneumatic anti-shock garment was found to be a useful adjunct in the management of the Flying Squad patient.

6.3.6 External cardiac massage

The role of closed cardiac massage in the resuscitation of injured patients before reaching hospital remains controversial (Bodai et al., 1983). In a review of 267 patients with cardiopulmonary arrest following trauma, Schimazu & Shatney (1983) concluded that patients with blunt injury involving the chest or abdomen are unsalvageable. Mattox & Feliciano (1982) reported 100 patients with blunt and penetrating truncal trauma who received cardiopulmonary resuscitation including cardiac massage for more than 3 minutes in the field; there were no survivors.

Accounts of trauma patients who have received external cardiac massage by paramedics during the pre-hospital phase and survive have been sporadically reported (Moore et al., 1979; Harnar et al., 1981). In general these patients were victims of penetrating thoracic trauma. Cardiopulmonary resuscitation and external cardiac compression also remain valuable in the care of trauma patients injured as a result of electrocution and lightning strikes and similar aetiologies which result in conduction abnormalities or ventricular fibrillation (Mattox and Feliciano, 1982). In the present study there were no survivors in patients injured as a result of either blunt of penetrating trauma and in whom pre-hospital external cardiac massage was performed. One patient who arrested following a "pre-cordial kick" from a horse had external cardiac massage performed by the ambulance crew. On arrival of the Flying Squad the patient was in sinus rhythm and had a regular pulse. The patient however required intubation and ventilation at the scene and during transfer.

In conclusion the results obtained from external cardiac massage for patients developing cardiac arrest following blunt trauma are uniformly dismal. External cardiac massage may however be of value in certain categories of trauma where an arrhythmia is produced. Although there were no surviving patients requiring external cardiac massage following penetrating injuries in this study, other workers have documented some success (Schimazu & Shatney, 1983). However in the context of an Accident Flying Squad response, this would only result in further delay in the field and result in increased mortality and morbidity (West et al., 1979).

6.3.7 Treatment time

Semmlow & Cone (1976) demonstrated an approximately linear increase between length of stay in hospital and Injury Severity Score values. A positive relation was also found in the present study although a wide scatter of treatment times was noted within each ISS cell. It is interesting to note that, unlike the mortality variable, the length of stay was sensitive to changes in ISS values in the low ranges. For example, although mortality was near zero for ISS values between 0 and 10, the average length of stay increased 3 times over this range. Bull (1975) also found a large scatter but the mean values of treatment times for given ISS ranges was significantly different. Because of the scatter, the treatment times of individuals could not be forecast from the Injury Severity Score but it can nevertheless be used for groups of cases to make comparisons of regimes of clinical management or for estimating cost of hospital stay. The mean hospital stay for patients treated by the Edinburgh Flying Squad within similar ISS ranges to those reported by Bull (1975) was noted to be less for each cell. However, there are perhaps too many variables to use this as an estimate of reduction in morbidity in respect of management administered at the scene.

6.4 Out-of-Hospital Cardiac Arrest

The emergency system first described by Pantridge & Geddes (1967) to resuscitate out-of-hospital cardiac arrest patients, utilised medical staff from the Cardiology Department. However the mobile unit responded to patients with chest pain rather than to cardiac arrest and in their 10 long term survivors with pre-hospital ventricular fibrillation the team were already present at or en route to the scene. Hampton et al. (1977) reported on a comparison of results from a cardiac ambulance manned by specially trained ambulance personnel only or by such personnel plus a doctor. There was no difference in mortality for out-of-hospital cardiac arrest patients. Subsequently, workers both in the United States (Eisenberg et al., 1980b) and the United Kingdom (Briggs et al., 1976) have demonstrated the success that can be achieved by the use of specially trained ambulance personnel alone. Eisenberg et al. (1980c) demonstrated an increase in discharge rates from 6 to 22% when such a system was introduced in Seattle to manage out-of-hospital cardiac arrest patients. The importance of rapid arrival of advanced life support has been confirmed repeatedly (Mackintosh et al., 1978; Cobb et al., 1980). Eisenberg et al. (1983) showed that if advanced life support is started in less than 6 minutes, 36% of pre-hospital cardiac arrest patients were discharged alive whereas if time was lengthened to 14 minutes the corresponding figure was only 9%.

Previous reports on the outcome of out-of-hospital cardiac arrest patients treated by Accident Flying Squads has been uniformly dismal. There were no successes in 9 patients treated by the Derby team (Rowley & Collins, 1979) and only one patient left hospital out of 24 pre-hospital cardiac arrest patients treated by the Leicester Flying Squad (Harrop & Bodiwala, 1983). Against this background therefore it is of concern that the Edinburgh Flying Squad is being used increasingly for medical emergencies and in particular out-of-hospital cardiac arrests. Although a long term survival rate of 8% was achieved by the team, Anderson and colleagues (1987) have pointed out that many patients successfully treated with an advanced technique might have survived had only a standard technique been available. The present study would appear to support the conclusion of previous workers that Accident Flying Squads are of little or no value in the pre-hospital cardiac arrest situations because of the time lag in mobilisation. The more widespread training of ambulance services in the use of advanced techniques including defibrillation will eliminate the necessity for Flying Squads to respond to such calls (DHSS, 1979). Additionally the use of Accident Flying Squads for other medical emergencies should be restricted to those situations in which there is an extraordinary difficulty with evacuation and transfer.

6.5 Mortality

Baker and colleagues (1974) noted, as might be expected, that patients with higher Injury Severity Scores tended to die earlier. In a study of 322 pedestrians injured from road traffic accidents, Fife (1987) reported that the median survival after injury was 2 hours for ISS 36-75, 7 hours for those with ISS 26-35, and 3 days for those with ISS below 26. The present study affirmed a positive relationship between ISS and survival although a wide scatter of ISS values were recorded in each time period. A similar finding was reported by Bull (1975) and his regression slope displaying ISS against logarithmic time scale was only just significant. The median ISS for patients dying at the scene despite intervention by the Flying Squad was 50 and was the same for those patients dying within 3 hours of admission to hospital. Baker et al. (1974) demonstrated in their original study, that in patients with an ISS of 50 or higher the percentage mortality at 6 hours from the time of injury was greater than 90%. They suggested that patients with Injury Severity Scores below 50 have the greatest potential for improved survival.

A strong relationship was found between Injury Severity Score and mortality and 96% of patients who died had sustained major trauma (ISS greater or equal to 16).
West et al. (1979) suggested that a low ISS amongst non-

survivors was an indicator of an inadequate trauma system when comparing an average ISS of 37 in Orange County, California, with 45 in San Franscisco. In a 5 year review of trauma deaths in Vermont, a panel of surgeons considered that the average ISS of preventable deaths was 40 (Certo et al., 1983). The mean ISS in their series was 46 and although the group considered that comaprisons of average ISS amongst dead patients is an inadequate system, a median ISS of 45 for patients who died despite treatment by the Flying Squad compares favourably with these American centres.

West et al. (1979) indicated that if similarity can be assumed between patients treated at a given centre and those patients in Baltimore, from which the Injury Severity Score was originally derived, then the ISS can be used to predict mortality and that centre could then compare its results to those of Baker's et al. (1974).
The Abbreviated Injury Scale grades of the most severe injury for patients treated by the Flying Squad was indeed found to be similar and Beverland & Rutherford (1984) also found this a useful method of comparison on which to base their assessment of validity of Injury Severity Score when applied to gunshot wounds. The original authors of the Abbreviated Injury Scale (Joint Committee on Injury Scaling, 1971), stated that the quantitative relationship of codes is almost certainly non-linear; evidence of this non-linearity was found in

the present study and confirms the findings of Baker et al. (1974).

This study demonstrated that for a given severity of injury as measured by the ISS, mortality increased with advancing age and agreed with the findings from larger series (Baker et al., 1974; Bull, 1975). The increase in mortality in the elderly is more pronounced when the injuries are least severe. It is interesting that neither the Trauma Score (Champion et al, 1981) which is a physiologically based score, nor the plasma cortisol, which is a measurement of endocrine disturbance (Stoner et al., 1977), appear to give a different relation to mortality with advancing years (Bull, 1983).

Stoner and co-workers (1977) affirmed that in mortality studies ISS must be weighted for age. However the broad age categories (15-44, 45-65 and 65+ years) used by Yates (1977) to correct for this influence may not be sufficiently sensitive. By constructing equal mortality contours for combinations of ISS and narrower age bands, Bull (1978) was able to more accurately define the age effect on mortality. For example from Bull's grid (Fig.3, p.39), predicted mortality ranges from 0.4 to 0.7 for patients aged between 45-64 years with Injury Severity Scores 25-29. This marked difference in predicted outcome between these two decades is not reflected in Yates' single age grouping.

The 5 point Injury Severity Score categories used in Bull's grid does not negate the greater sensitivity over Yates' extended survival lines (Fig. 2, p.38) as the ISS scale is discontinuous anyway with only 44 possible scores, the gaps becoming more frequent as the scores approach the maximum possible value of 75 (Stoner et al., 1977). The difference obtained between predicted and actual outcome when using Bull's grid as opposed to Yates' method reflects the degree of sensitivity with which these two methods take into account the influence of age on mortality. Similar work reported from those evaluating the treatment of burn injury have favoured the narrower age bands represented within mortality grids when producing appropriate age correction (Bull, 1971). Therefore as the mortality grid is the more sensitive indicator, the evidence provided in this thesis using Bull's method of comparing the actual mortality against predicted mortality (Fig. 29, p.124) has been accepted in preference to the comparison of actual survival against predicted survival (Fig. 28, p.123) described by Yates.

One of the most important current functions of severity indices is in evaluating and comparing the quality and outcome of an emergency care system over a period of time (Gibson, 1981). It has been used in this respect to define "acceptable care" (Moylan et al., 1976) and preventable deaths (Certo et al., 1983). Although review of individual charts and post-mortem reports in a series of patients can provide useful information (Baker, 1971) a yearly audit using the Injury Severity Score had the advantage of providing an objective method of evaluation; in this study of the function of the Flying Squad during its period of operation. In addition, it has proved sensitive in pinpointing areas that require further appraisal to determine if a death was preventable.

In reviewing the evidence for and against "on site" resuscitation in the United Kingdom, Stoner & London (1982), indicated that sophisticated techniques would be needed to demonstrate any advantage of Accident Flying Squad schemes "since the number of lives which could be saved by these methods is probably small". Baseline chi-square analysis was found to be straightforward in its application and provided a useful approach to the question "do Accident Flying Squads save lives?" As with any statistical procedure care is required in interpreting the results. The baseline chi-square analysis provides a means for a unit to compare its survival rate with that of a baseline and give some indication of the sensitivity of that comparison.

The baseline used for the control in this study was derived from an analysis of a single series of patients admitted to the Birmingham Accident Hospital in 1961.

Clearly caution is required in the use of such an historical control; the difference between actual and predicted mortality could be attributed to other advances in the management of trauma patients rather than to the treatment provided by the Edinburgh Flying Squad. However it has been acknowledged by the Royal College of Surgeons of England (1988), reporting on the management of patients with major injuries, that the Birmingham Accident Hospital reached "heights of excellence" in the treatment of such patients. The working party also highlighted deficiencies in the management of multiply injured patients and now recommend the development of trauma centres based on the principles which Professor William Gissane had established in the 1960s. In addition the results achieved in Birmingham were shown to be almost identical to those reported from Baltimore and Illinois, two of the leading trauma centres in the United States, almost 15 years later (Baker & O'Neill, 1976; Semmlow & Cone, 1976). There is at present no other U.K. trauma baseline on which to make useful comparisons of patient care. However the Major Trauma Outcome Study presently being coördinated from Manchester may provide the answer in the future.

The chi-square analysis offers advantages over other methods of baseline comparisons (Stern & Waisbern, 1976). For example, the analysis suggested by Flora

(1978) may result in a unit which has better survival rates in certain categories of patient severity but a poor survival rate in others having an average survival similar to the baseline. The chi-square method on the other hand will detect a significant result within any particular cell. The cell with the highest chi-square increment in the present study fell within the group of severely injured patients with Injury Severity Scores of 41-55. Thus the method satisfactorily defined that population of patients in whom one might expect that measures taken at the scene by the Flying Squad would contribute to survival. Although the baseline chi-square analysis suggested that Accident Flying Squads do save lives, the number is small. Nevertheless with the average cost of a road accident fatality in the United Kingdom presently estimated at £200,000 the Edinburgh Flying Squad would appear to have amply repaid both the initial outlay and subsequent running costs.

APPENDIX I

FLYING SQUAD EQUIPMENT

REAR COMPARTMENT

Cardiopulmonary resuscitator
Medical antishock trousers
Portable anaesthetic machine
ECG monitor/defibrillator
ECG monitor battery charger
2 oxygen cylinders and spanner
Entonox cylinder
1 portable suction machine
  5 Yankauer suction catheters
  10 suction catheters size 14
  5 suction catheters size 12
  5 suction catheters size 10
1 set Vacuum splints (3)
1 Hare traction splint
1 set jet plints (6)
3 cervical collars
1 stainless steel basin
2 bottles saline for irrigation
3 pairs each sterile gloves sizes 6, 7, 7 1/2, and 8
1 box Haemaccel
1 box normal saline
2 bags Mannitol 20%
2 bags Sodium bicarbonate 8.4%
2 bags Dextrose 5%
1 box IV giving sets (10)
2 chest drainage sets
Shock charts on clipboard
5 protective helmets
2 waterproof suits
1 site medical officer tabard

Flying squad packs
  Tracheostomy
  Amputation
  Cut down

Major incident packs
  Tracheostomy
  Amputation
  Cut down

Fridge: 1 box pancuronium
  1 box suxamethonium
  1 box velosulin

2 Resuscitation cases
  1 Adult IV/airway
  1 Child IV/airway

Drug case

NEAR SIDE COMPARTMENT

2 Adult resuscitation cases
1 Child resuscitation case
1 Chest case
1 Ventilation case
1 Dressing case

Spare cylinders
Oxygen
Nitrous oxide
Entonox

PASSENGER COMPARTMENT

4 Multithene jackets
2 pairs waterproof trousers
1 box unsterile gloves
UHF hand radios
Maps
1 bag normal saline
1 intravenous giving set
1 spotlight

APPENDIX II

RESUSCITATION CASE (ADULT)

LID

Endotracheal tubes sizes 9.5, 9.0, 8.5, 8.0, 7.5 mm
ETT introducer
1 syringe 20 ml
1 Macbic clamp
1 tube K-Y jelly
1 Lignocaine spray
1 crinx bandage 5 cm
1 laryngoscope
1 laryngoscope bulb
2 batteries size C
1 mouth gag
1 pair Magills forceps
1 pair tongue forceps
1 catheter mount
Guedel airway sizes 2, 3 and 4

BOTTOM

2 Medicut intravenous cannulae size 16G
2 Venflon intravenous cannulae size 18G
2 Butterfly intravenous cannulae size 21G and 23G
1 intravenous giving set
2 Surcaths 12" long
2 syringes 10 ml
Needles 21G and 23G
Mediswabs
1 medium tourniquet
2 sequestrene blood tubes
2 plain blood tubes
2 clothes cutting scissors
1 Listers bandage scissors
1 Haemaccel
1 Normal Saline 500 ml
1 adhesive tape
1 elastoplast 7.5 cm
2 crepe bandages 7.5 cm
1 silk suture
1 polythene bag
Non sterile swabs
1 plastic splint

A child Resuscitation Case contains similar equipment differing in sizes only.

APPENDIX III

CHEST CASE

LID

1 Aneroid sphygmomanometer
1 Miniscope
1 adult miniscope lead adaptor
1 child miniscope lead adaptor
1 visor
4 batteries size C
1 gastric aspiration box - nasogastric tubes sizes 10, 12, 14 and 18
- 1 catheter tipped syringe
- 1 tube K-Y jelly
- Non sterile swabs
- 1 Traysin
- Elastic band
- Small polythene bag

BOTTOM

1 chest drainage set
2 pairs sterile gloves
1 Betadine spray
1 roll sleek 7.5 cm
2 ampoules Lignocaine 2% 5 mls
1 roll elastoplast 7.5 cm
1 large artery clamp
1 pair scissors
2 each Thoracic cannulae sizes 14G, 18G, 24G and 28G

APPENDIX IV

VENTILATION CASE

LID

Ambu bag
Face masks size 2 and 4
Connector tubing
2 Hudson oxygen masks
Pneupac ventilator

BOTTOM

2 mini nebulisers
Emergency aspirator and suction catheters
2 syringes 10 ml
4 ampoules sterile water
1 bottle salbutamol solution
2 ampoule files

APPENDIX V

DRUG CASE

LID

2 Minijets Dextrose 50%
1 box Thiopentone 0.5 g with water to reconstitute
1 box Brietol Sodium 500 mgs with water to reconstitute
1 bottle Dextrostix
1 skin pencil
4 ampoules Decadron 4 mg/ml
1 bottle Fluothane
2 Minijets Aminophylline 250 mgs
2 Minijets 20% Lignocaine
1 Polyfusor Sodium Bicarbonate 8.4%
2 Minijets Frusemide 80 mgs
1 box Hydrocortisone 100 mgs/ml
1 pack Methyl-prednisolone 1 grm

BOTTOM

1 box Atropine 0.6 mg
1 box Calcium gluconate 10%
1 box Practolol 10 mg/5 ml
1 box Verapamil 5 mg
1 box tourniquets
1 box Isoprenaline 2 mg
1 box Adrenaline 1:1000
1 box Isoprenaline 0.1 mg
2 Minijets Lignocaine 100 mg
2 boxes Cyclimorph 10 mg
1 box Pentazocine 60 mg
1 box Cyclizine 50 mg
2 boxes Naloxone 0.5 mg
1 box syringes 10 mls and 2 mls
1 box mediswabs
2 Insulin syrings

APPENDIX VI

DRESSINGS CASE

LID

4 bandages crinx 20cm
3 bandages crinx 7.5 cm
4 bandages triangular
2 incontinence pads
1 collar and cuff
4 bandages crepe 15 cm
4 bandages crepe 10 cm
4 bandages crepe 7.5 cm
3 bandages crepe 5 cm

BOTTOM

6 packets sterile swabs
1 box airstrip assorted sizes
8 surgipads 20 x 20 cm
1 elastoplast 7.5 cm
1 elastoplast 5 cm
1 elastoplast 2.5 cm
1 adhesive tape
1 torch magnetic
3 packets sterile swabs 7.5 cm
1 pair Listers bandage scissors
1 box assorted safety pins
2 sterile eyepads
2 Amethocaine minims

APPENDIX VII

TRACHEOSTOMY PACK (FLYING SQUAD)

2 sponge holders
6 towel clips
10 Criles artery forceps
2 Spencer-Wells straight artery forceps
1 scalpel handle number 4 with number 23 blade
1 scalpel handle number 3 with number 11 blade
1 pair straight Mayo's scissors
1 pair Metzenbaum's scissors
1 self retaining retractor
2 small Langenbek's retractors
1 sharp hook retractor
1 blunt hook retractor
2 Allis tissue forceps
1 pair Waugh non-toothed dissecting forcep
1 pair Waugh toothed dissecting forceps
1 tracheal dilator
1 catheter mount and connector
2 green drapes
1 gallipot
20 theatre swabs

The Tracheostomy Pack for major incidents differs in quantity only.

APPENDIX VIII

AMPUTATION PACK (FLYING SQUAD)

4 green drapes
2 gallipots
2 kidney dishes
20 x 5" theatre swabs
2 x 4" crepe bandages
2 x 6" crepe bandages
1 latex rubber drain
1 corrugated rubber drain
2 large pieces Gamgee
1 amputation saw
2 sponge holders
6 towel clips
10 curved Mayo artery forceps
2 straight Mayo artery forceps
1 pair Mayo curved scissors
2 scalpel handles and blades no 23
2 pairs toothed dissecting forceps
2 pairs non-toothed dissecting forceps
2 occlusion clamps
2 large rake retractors
2 small rake retractors
1 Mayo needle holder
1 Gigli saw
4 pairs Allis tissue forceps
Selection of chromic catgut and silk sutures

Equipment contained in Major Incident Amputation Pack differs in quantity only.

APPENDIX IX

CUT DOWN PACK (FLYING SQUAD)

1 scalpel handle no. 3 with no 15 blade
4 Halstead's artery forceps
1 blunt hook
1 aneurysm needle
1 pair straight scissors
1 pair Lane's toothed forceps
1 Mayo needle holder
1 Gallipot
10 swabs
2 medium drapes

Major Incident Cut Down Pack differs in quantity only.

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* References marked with an asterisk have been read in abstract only.

Publications

The aspects of this thesis which have already been published are listed below

Steedman D.J. and Robertson C.E. (1986)
Accident Flying Squads - An objective evaluation of their role in trauma. Journal of the Royal College of Surgeons of Edinburgh 31, 80-4.

Robertson C.E. and Steedman D.J. (1986)
Are Accident Flying Squads really cleared for "take off"? Lancet 2, 434-6.

Accident flying squads: an objective evaluation of their role in trauma

D J Steedman and C E Robertson**

An objective evaluation of an Accident Flying Squad was performed using an Injury Severity Scoring system. A retrospective analysis of 73 trauma patients treated at the scene failed to confirm the subjective judgement of the benefits of treatment in this group. We recommend that further studies should be carried out to determine whether the failure to document reduction in mortality is due to defects in the method of assessment and small patient numbers or whether it genuinely reflects absence of benefit of such squads.

There has been a dramatic increase in the number of hospital based Accident Flying Squads in the United Kingdom since the first scheme was established by Collins at Derby Royal Infirmary in 1955[1 2]. Despite the recent claims of "the undoubted value of flying squads"[3] there is a paucity of objective data to support the role of such schemes in reducing mortality and morbidity. Indeed it has been suggested that it is impossible statistically to justify a Flying Squad's existence. Several workers have reported on their experience in this field of emergency medical care, but although considerable detail has been supplied in relation to call-outs, evaluation has been based on subjective assessment[2 5].

One of the major difficulties encountered in assessing treatment of trauma patients relates to the multiple injuries which are sustained and to the effect of the combination of these injuries. It is essential to define the severity of injury in a quantitative way before any statistically significant statement can be made about the benefits of treatment[6]. One grading system for assessing patients with multiple injuries is the Injury Severity Score (ISS)[7 8], derived from the Abbreviated Injury Scale (AIS)[9]. This system has been utilised in the present analysis to evaluate the efficacy of the Accident Flying Squad based at the Edinburgh Royal Infirmary in response to trauma call-outs.

Patients and methods

The Accident and Emergency Department at the Edinburgh Royal Infirmary is the central Accident Unit for the Lothian and Border regions with a population of approximately 750,000. The Flying Squad was established in 1980 and provides an emergency medical and nursing team on a 24-hour basis. The Flying Squad vehicle is a specially modified Bedford chassis van which has radio communication with the ambulance services and carries a comprehensive range of resuscitative equipment. The team usually consists of one or two experienced numbers of nursing staff, a doctor of Consultant or Registrar grade and one Senior House Officer, while the van is driven by ambulance personnel.

The first 100 call-outs, which occurred between January 1980 and February 1983, have been analysed retrospectively. Information was obtained by reference to the log-book, departmental records, in-patient notes and (in all cases who died as a result of their injuries) to post mortem reports. Details collected included: age and sex of patient; type of incident; nature of injuries; treatment given; and survival.

An injury severity score was derived for each patient tended at the scene by the Flying Squad.

The Abbreviated Injury Scale and the injury severity score

The Abbreviated Injury Scale refers to the assignment of a single code number on a scale 1–6 for specific injuries. The 1980 revision of the AIS contains more than 500 such injury descriptions. Five separate criteria (energy dissipation, threat to life, permanent impairment, treatment period and incidence) were considered in the development of the AIS. Thus for each body region, a minor injury would attract an AIS severity code of 1; a moderate injury 2; serious 3; severe 4; critical 5; and maximum injury (unsurvivable with current techniques) 6. This numerical code 1–6 is not a linear progression and therefore does not allow for the taking of an arithmetic mean when applied to multiple injuries[9].

The Injury Severity Score is derived from the AIS and based on analysis of 2128 road traffic accident victims in Baltimore[7 8].

For the purposes of Injury Severity Scoring the body is divided into 6 regions: head and neck; face; chest; abdominal and pelvic contents; limbs and pelvic girdle; and external. An AIS code of 1–6 is then assigned to each injury. The ISS is calculated by adding the squares of the highest AIS code in each of the three most severely injured body regions. An example is shown in Table 1. The maximum score for any one region is 25 (excluding the AIS code of 6), and the highest possible ISS is thus 75. Any patient with an injury severe enough to attract an AIS code of 6 is automatically awarded an ISS of 75. The Injury Severity Score provides suitable weighting for the AIS and allows for the proper combination of the effects of multiple injuries.

In mortality studies the ISS value must be weighted for age, for older patients are more likely to die from less severe injuries than younger patients. Bull[6] used Probit analysis[10] to linearise the mortality data in separate age groups in relation to 1333 road traffic accident patients admitted to the Birmingham Accident Unit. He found that an ISS of 39.7 ± 2.9 (mean $\pm$ SD), 29.4 ± 2.5 and 20.2 ± 1.6 were associated with 50% mortality in

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TABLE 1

Injury severity scoring

Area	*Injury*	*AIS*	*AIS²*
Head	R subdural haematoma	4	16
	Unconscious, appropriate movements to painful stimuli	4	
Face	—		
Thorax	L lung contusion	3	9
	Fracture 1–2 ribs	1	
Abdomen	Ruptured spleen	4	16
	Superficial liver lacerations	3	
	Pancreatic laceration	3	
	Mesenteric contusion	3	
	Retroperitoneal haematoma	3	
Extremities pelvic girdle	Fracture pubic ramus	2	
External	Laceration R eyebrow	1	

ISS = 16 + 9 + 16 = 41 Call 79

the respective age groups 15–44 years, 45–64 years and 65+ years (there were insufficient cases in the 0–14 age group for Probit Analysis). In our study age weighting was produced by correcting the ISS value of patients to that appropriate for the 45–64 age group using Yates modification[11] of Bull's Probit analysis[6] (Fig 1). For example, a patient aged 70 with an ISS of 30 has an age corrected score of 40. Yates included a predicted chance of survival in his modification and was utilised in our own analysis to predict the overall chance of survival for those patients who received treatment at the scene.

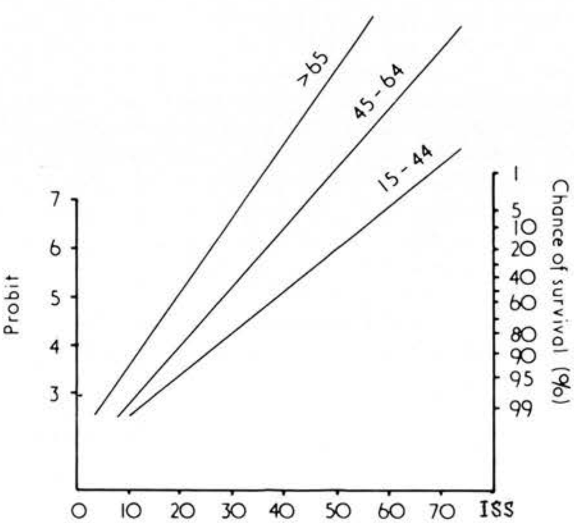

Fig 1 Relation between ISS and survival. (Yates modification[10] of Bull's probit lines[6]. Probit lines have been extended to allow translation of scores for younger and older age-groups on to the line representing middle age-group.

Bull[12] also derived a grid of expected mortality for different combinations of ISS and age groups above 15 years based on his initial data (Table 2). Patients were divided into decades and ISS into equal groups 0–4, 5–9, 10–14 etc. An approximate probability of mortality was obtained for each age group and ISS. For example, a patient aged 25–34 with an ISS 40–44 would have an approximate probability of mortality of 0.7. The grid was used as another method of determining the predicted mortality of patients treated by the Edinburgh Flying Squad.

Results

58 calls were related to trauma and involved 88 patients (Table 3). The precipitating cause of injury is shown in Table 4. The precipitating cause of death is given in Table 5 and the place and time of death in Table 6.

2 patients could not be adequately scored using the ISS system. The first was a 15-year-old boy who died from asphyxia secondary to crush injury of the chest when he was trapped beneath a stone slab. The second was a 17-year-old motorcyclist involved in a road traffic accident who was strangled by his crash helmet strap; this together with a car resting on his lower rib cage led to hypoxic brain damage.

17 patients who died were alive when the Flying Squad arrived. At the scene, 15 of these patients had absent major pulses and absent or agonal respiration, but nevertheless resuscitative measures were attempted. The lowest scoring death (ISS 26) was that of a man who died at the scene having sustained a gunshot wound to the thorax. The highest ISS amongst the survivors was 50.

17 patients required endotracheal intubation including one patient (ISS 16) who had transected his trachea with a knife necessitating the placement of a tracheostomy tube to maintain an adequate airway. 5 of the patients

TABLE 2

Approximate probability of mortality for different combinations of ISS and age*

ISS	Age (yr) 15 < 25	25 < 35	35 < 45	45 < 55	55 < 65	65 < 75	75 < 85
55 < 60	1.0	1.0	1.0	1.0	1.0	1.0	1.0
50 < 55	0.9	0.9	1.0	1.0	1.0	1.0	1.0
45 < 50	0.7	0.8	0.9	1.0	1.0	1.0	1.0
40 < 45	0.6	0.7	0.8	0.9	1.0	1.0	1.0
35 < 40	0.4	0.5	0.6	0.8	0.9	1.0	1.0
30 < 35	0.3	0.3	0.5	0.6	0.8	0.9	1.0
25 < 30	0.2	0.2	0.2	0.4	0.7	0.8	0.9
20 < 25	0.1	0.1	0.1	0.2	0.3	0.5	0.8
15 < 20	0	0	0	0.1	0.1	0.3	0.5
10 < 15	0	0	0	0	0	0.1	0.3
5 < 10	0	0	0	0	0	0	0.1
0 < 5	0	0	0	0	0	0	0

*Bull[12]

requiring such specific airway management survived. 43 patients who survived received an intravenous infusion at the scene, 24 of whom were noted to have signs of hypovolaemic shock. This group included 7 patients whose transfer to the Accident and Emergency Department was delayed because of entrapment. 20 patients received intravenous analgesia, including 16 patients requiring extrication or release from impalement. 4 patients had a chest drain inserted. One patient died at the scene (ISS 29), one patient died on returning to the Accident and Emergency Department (ISS 33) and 2 patients died following admission, one at 3 days (ISS 29) and one at 6 days (ISS 57).

The distribution of ISS is given in Fig 2 together with the corrected scores to the 45–64 age group. The Probit analysis is not applicable to patients under 15 years, therefore 5 children who survived and 2 who died have not had their scores corrected. Of the 79 patients who did have their scores corrected, 6 were dead when the Flying Squad arrived and therefore were excluded from the analysis.

TABLE 3

Types of call

Type of call	*Total number of calls*	*Total number of patients*
Trauma	58	88
Medical	22	22
Aborted	16	(0)
Airport alert	4	(0)
Total	100	110

TABLE 4

Precipitating cause of injury

Cause	*Number of calls*	*Number of patients*
Road traffic accident	35	62
Industrial works	8	8
Domestic	8	11
Suicide	6	6
Assault	1	1
Total	58	88

TABLE 5

Number of deaths by cause

Cause	*No. of patients*	*ISS range*
Road traffic accident	16	29–75
Domestic	3	33–50
Suicide	3	29–57
Assault	1	26
Total	23	

TABLE 6

Time and place of death

Time of death	*No. of patients*	*ISS range*
Dead when flying squad arrived	6	51–75
Died at scene	5	26–75
Died within 24 hours of admission	7	33–75
Died later than 24 hours	5	29–57
Total	23	

Applying the predicted chance of survival described by Yates[11] to the remaining 73 patients, 59.4 were expected to survive and 59 actually survived.

The predicted mortality for the 73 patients alive when the Flying Squad arrived using the mortality grid of Bull[6] was 14.7 and 14 patients actually died.

Medical calls

Twenty-two calls were related to medical conditions. 11 patients received cardiopulmonary resuscitation at the scene. 3 patients were successfully resuscitated. However, one patient subsequently died on return to the Accident and Emergency Department and the other 2 patients died

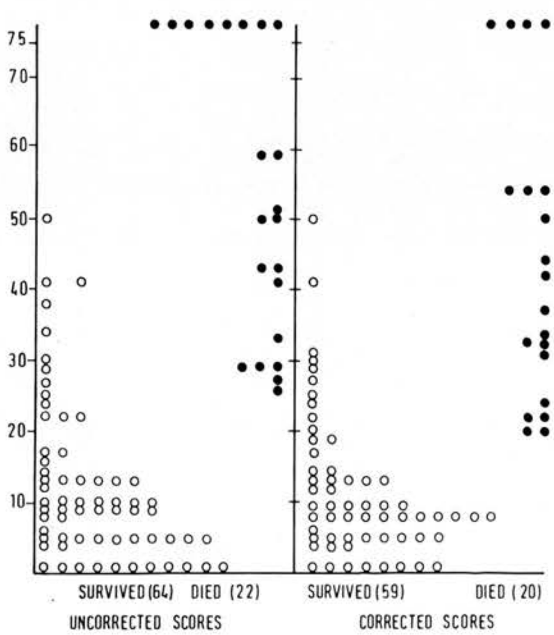

Fig 2 Distribution of Injury Severity Scores.

5 days and 14 days following admission. In 2 further "cardiac arrest" calls the patients had regained cardiac output and were ventilating spontaneously prior to the arrival of the Flying Squad. Both patients survived to leave hospital.

3 patients who had sustained a myocardial infarction received treatment for arrhythmias and cardiac failure before being transferred to the A & E Departments; 2 survived.

One patient who survived following an acute drug overdose required endotracheal intubation to maintain an adequate patent airway.

5 other medical patients who survived received treatment at the scene for massive pulmonary embolism, acute hypoglycaemia and status epilepticus.

Discussion

This study is presented as much for its method as for its results and highlights the difficulties encountered in evaluating the immediate care provided by Accident Flying Squads in relation to trauma. In 1982 a survey indicated that there were 47 centres in the United Kingdom which operate such schemes[1]. For a method of emergency care which has been available for 30 years, it is disturbing that there has been little objective assessment to confirm the many subjective judgements of benefit.

The introduction of the Injury Severity Score has facilitated research in this field: the first objective evaluation of an Accident Flying Squad was performed in 1983 by Gorman and Coals[13] from Chester. When the predicted chance of survival was applied to 152 trauma patients who received treatment at the scene, 110.12 were expected to survive and 110 actually survived. The grid described by Bull was then used to predict mortality: according to this, 44.1 patients were expected to die and 42 actually died.

In our own study there was no objective evidence to confirm that treatment carried out at the scene of the accident saved lives. Failure to demonstrate the effectiveness of the Flying Squad may be due to deficiencies in the assessment process rather than to the use of the Squad *per se*.

The analytical method we used offers a basis of comparison of outcome between the populations seen by the Edinburgh Flying Squad and that used in Bull's Probit Analysis. However, there may be many differences between the populations apart from the use of the Flying Squad which is our particular focus of interest. Certain inconsistencies also arise in the use of the Injury Severity Score. While the ISS is well validated for blunt trauma it does not appear to reflect accurately the severity of injury when applied to penetrating trauma[14]. Injuries associated with stabbings and gunshot wounds yield inappropriately low scores using such a scheme. Another situation in which difficulty is experienced is in assigning scores to asphyxiating-type injuries. It is possible that refinements of the ISS are required before it can be justifiably applied to Accident Flying Squads; indeed, it may be that some other scoring system is necessary[15].

Although most Flying Squads are designated by the prefix "Accident", a significant proportion of their workload is related to medical cases which accounted for one-third of calls responded to during the period of this study. Objective assessment of their efficacy in this area is even more difficult to determine. Rowley[17] reported that medical cases attended by the Derby Royal Infirmary Flying Squad represented 20% of all the calls. The outcome for these medical cases was uniformly dismal; indeed, all ultimately died before discharge from hospital except for 2 children who had had epileptiform convulsions.

Although the equipment and techniques involved in on-site resuscitation have become progressively more sophisticated, it is relatively inexpensive to equip a flying squad—£10,000 to £20,000 including the vehicle concerned[16]. Running costs are minimal, but depreciation of the vehicle used will add to the costs substantially.

Nevertheless, if such squads can be shown to save even one life, they would have amply repaid both their initial outlay and subsequent running costs. With nearly 500,000 persons sustaining major injury from trauma in the UK each year, the potential use of Accident Flying Squads is great[16]

However, further studies are indicated to determine whether the failure to document objective reductions in mortality and morbidity is due to defects in Injury Scoring assessment and small patient numbers, or whether it genuinely reflects an absence of benefit in the operation of such squads in response to trauma calls.

Acknowledgments. Our thanks to Dr Keith Little for his helpful advice and to Mr J Douglas-Allen, Regional Procurator Fiscal, for permission to examine the autopsy reports.

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Emergency Care

ARE ACCIDENT FLYING SQUADS REALLY CLEARED FOR "TAKE-OFF"?

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THE concept of "first aid to the wounded" is not new. Napoleon's surgeon-in-chief, Dominique Jean Larrey appreciated the requirement for rapid evacuation and early medical care when he set up the celebrated "flying ambulances" in the first half of the 19th century but it was only in the latter part of the 1939–45 war that modern techniques of resuscitation came to be applied to wounded personnel at the place of injury. Subsequently, during the military conflicts in Korea, Vietnam, the Middle East and more recently in the Falklands, specifically trained "paramedic" soldiers provided basic medical care and rapid evacuation of the seriously injured.

The application of lessons learnt during war-time to civilian experience is often delayed. Nowhere is this more powerfully exemplified than in the establishment of hospital-based accident flying squads. In 1955 the first accident flying squad was established by Collins at the accident and emergency department in Derby Royal Infirmary.[1] In the early 1970s several other centres within the United Kingdom began to appreciate the potential value of such squads, and the number of schemes has since increased rapidly. In 1982 there were 47 centres throughout the United Kingdom with this facility, but less than half of these were "active", with 10–100 call-outs per annum.[2]

THE CASE FOR ACCIDENT FLYING SQUADS

In Great Britain approximately 6000 people die every year as a result of road traffic accidents. Three times this number of people are killed in accidents in other situations and nearly half a million people sustain major injuries each year from trauma. It has been suggested that 43% of motorcyclists and vehicle occupants who die as a result of road traffic accidents may have had a greater chance of survival had medical treatment been available at the scene within 10 min of the injury.[3] In advocating a role for accident flying squads it is therefore essential to delineate those groups of patients who would benefit from the provision of early emergency care.

The two major preventable causes of death following trauma are respiratory obstruction and/or inadequate ventilation, and hypovolaemia. Several attempts have been made to quantify these components. Lauppi indicated that 14% of patients who died within 2 days of their injury did so because of respiratory obstruction. Ruffnell-Smith reported the frequency of death from respiratory obstruction to be 5%.[5] In a major study in 1976 casualty officers found airway obstruction in 10·7% of patients who died as a consequence of trauma, but only in 0·7% of survivors. They also reported inhalation of blood and vomitus in 36% of all deaths related to road traffic accidents.[6] In 1982 the same workers reported that nearly 40% of patients who subsequently died had an obstructed airway at the scene of the accident.[7] In Yates' study of deaths over a 5 year period, of patients who died in hospital as a consequence of trauma, those who had airway obstruction had less severe injuries as measured by a standard scoring system than did those without such obstruction.[8] This finding strongly implied that airway obstruction in such a context contributed to mortality.

The situation with regard to blood loss is less well documented. Hoffman showed that for patients who died with associated blood loss, 59% died instantly and 85% died within 6 h, suggesting that perhaps 25% of deaths from hypovolaemia could have been prevented.[7] Sherriff has suggested that 33% of patients who died of trauma from road traffic accidents did so because of blood loss and that 7–10% of these could have been saved by adequate intravenous infusion.[9]

Although these various studies have been criticised on grounds of irreproducibility and subjectivity, it would nevertheless appear that there is a sizeable proportion of patients whose deaths could have been prevented had medical aid been immediately available.

ORGANISATION OF FLYING SQUADS

Having decided that flying squads have potential value in providing emergency medical care at the scene, one must consider the type of personnel and equipment best suited for providing such a service.

Snook has reported his experience of personal attendance as accident medical officer to the Bath Fire and Ambulance Service;[10] however, a single-handed service of this type has obvious limitations. Most workers consider that a team consisting of senior doctors from the accident and emergency department together with specially trained nursing staff should attend such calls. In Edinburgh, where a flying squad has been functioning for the past 5 years, the usual team

O. SIMONEN AND O. LAITINEN: REFERENCES—*continued*

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comprises a senior member of medical staff (consultant or registrar grade), one senior house officer, and one or more experienced nurses. A call-out would therefore deplete the complement of staff in the base department if arrangements were not made to provide adequate cover. Accordingly most accident flying squads operate from large, usually teaching, hospital accident and emergency departments which have 24 h staffing at senior level.

Most centres operating such schemes use transport provided by the ambulance service and only 6 centres in the United Kingdom have their own flying squad vehicle; these vehicles have usually been funded by public donation or the area health authority. Despite the crucial nature of communication only 60% have their own radio links with the emergency services.[2] Considerable experience has been gained with respect to the nature of resuscitative equipment necessary for the provision of immediate medical care. Usually the equipment is assigned for use specifically by the flying squad and adapted for the vehicle that has been designated for use by the team. Over the past decade such equipment has become progressively more refined, sometimes the result of innovations made by members of flying squads.[11,12] A considerable proportion of casualties are trapped and extrication requires special equipment. This is normally carried by fire service vehicles although several squads carry a limited range of hydraulic ram, saws, shears, and jacks.

The roadside is not the place for complex medical or surgical intervention. Provided the basic priorities of airway patency, ventilation, volume replacement, pain relief, and splintage can be achieved, little more is required in the vast majority of cases before transfer to hospital. The corollary of this is that it is not too expensive to fully equip a flying squad; £10 000–15 000 would be sufficient today.

EFFICACY OF FLYING SQUADS

With the wisdom of hindsight, it seems extraordinary that no attempt was made until the early 1970s to assess the influence of flying squads in reducing mortality or morbidity. In Collins' original paper in 1966, his conclusion that "the success of early treatment of the injured by the flying squad has amply justified the efforts of the team"[1] was not supported by objective data. Snook judged that attendance by his flying squad at an accident was of direct medical value for 1 in 3·5 calls.[10,12] He outlined a group of patients whose deaths had been "probably possible" to prevent. He stated that in 302 casualties immediate medical treatment was responsible for the survival of 6 patients and contributed to the survival of a further 4 patients—ie, it saved the lives of 3·3% of patients. His justification for this analysis was entirely subjective although considerable detail regarding each of the cases was given. In 1976, Little analysed data from 403 patients treated by the Derby flying squad between 1967 and 1972.[13] He pointed out that "there are few patients whom one can categorically prove had their lives saved by the flying squads, but there are many whom on clinical judgment should not have survived but did". His overall conclusion was that 48% of patients treated by the flying squad had materially benefited by such early treatment and that 17·5% had had their lives prolonged or saved.

The injury severity score (ISS) introduced in 1974 helped in the objective description of differences in the severity of injuries in relation to morbidity and mortality for various groups of patients.[14-16] Other workers have confirmed the validity of the Baltimore group's work. Bull reported on more than 1000 road traffic accident victims who were subsequently treated at the Birmingham Accident Hospital.[17] He used probit analysis to obtain mortality data for different age-groups and showed that the ISS values in his series bore a direct relation to the clinical severity of the injury as measured by variables such as mortality, duration of survival, hospital treatment, and subsequent disablement. By means of probit analysis he was able to provide "the LD_{50}" for young, middle-aged, and elderly adults. In 1977 Stoner and co-workers did a similar analysis on patients injured in road traffic accidents or other circumstances.[18] Their results overwhelmingly endorsed the use of the ISS as a powerful epidemiological tool and also showed that the ISS values seemed to be directly related to the amount of force required to cause the injuries.

The first objective evaluation of a flying squad scheme was done in 1983. Of the 152 patients treated by the Chester flying squad between 1974 and 1981,[19] 110·1 patients were expected to survive and 110 actually did survive. According to the method described by Bull 44·1 patients were expected to die and 42 actually died—thus it would seem that the action of the Chester flying squad saved 1·3% of the viable patients. The statement that on clinical grounds 6% of those alive at the scene remained alive because of treatment given on the spot seems difficult to justify. A similar retrospective analysis in 1984 of the Edinburgh flying squad experience showed that the predicted survival and mortality was identical to that actually observed.[20]

DIFFICULTIES IN EVALUATING WORK OF FLYING SQUADS

There are few reports on the work of individual flying squads and, where information is available, conclusions are handicapped by the small numbers of subjects. Moreover, the methods of scoring used in these studies may not be appropriate. Although the abbreviated injury scale and the derived injury severity score have been well validated for the blunt injuries which occur in road traffic accidents, inconsistencies occur in their application to penetrating injuries. Thus injury associated with stabbing and gun-shot wounds would be scored inappropriately low by the use of such a scheme. The scores are also not applicable to asphyxiating type injuries or to non-traumatic emergencies. Perhaps new or refinements of existing scoring systems are required.[21]

Another factor that makes evaluation of the work of flying squads difficult is that although most of them are designated by the prefix "accident", a considerable, and rising, proportion of their workload is of "medical" cases. For example, the medical cases attended by the Derby Royal Infirmary flying squad represented approximately 20% of their calls.[22] The outcome for these medical cases was uniformly dismal; indeed all ultimately died before discharge from hospital except for 2 children who had epileptiform convulsions. Our experience over 5 years in Edinburgh has been similarly disappointing with only a handful of medical cases surviving to leave hospital.

It is important to look a little further at this area of medical accidents since several well-publicised groups have shown considerable success in cardiopulmonary resuscitation out of hospital.[23-25] Why then is there such a difference between the results obtained by flying squads and those obtained by coronary-care teams, which are usually staffed by "paramedical" workers? No doubt one of the most important reasons is the method by which the flying squads are contacted. Most coronary-care ambulances are citizen-activated, which results in minimum delay in mobilising the team. Flying squads are called only after initial assessment either by a member of one of the emergency services or a doctor. Secondly, the best results in cardiopulmonary resuscitation out of hospital have occurred where lay bystanders have initiated basic life-support and continued this until advanced cardiac life support is available from specialised services.

CONCLUSIONS

The validity of blanket statements indicating that flying squads "undoubtedly save lives"[26] must remain severely open to question. What can, however, be stated with some certainty is that throughout the United Kingdom such squads continue to be formed, and although they are well equipped and generally well staffed, most receive few calls a year. The few attempts at assessment of results have not shown any major improvements in mortality and morbidity, although anecdotal evidence of the efficacy of flying squads has proliferated as fast as the squads themselves.

Although it seems logical that flying squads contribute to the management of critically ill patients whose condition could be expected to deteriorate before or during transfer to hospital, their existence must still be considered to be based on empirical and emotional appeal rather than on scientific evidence of their value.

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World Health Organisation

APPROPRIATE TECHNOLOGY FOR BIRTH

In April, the European regional office of the World Health Organisation, the Pan American Health Organisation, and the WHO regional office of the Americas held a conference on appropriate technology for birth. The conference, held in Fortaleza, Brazil, was attended by over 50 participants representing midwifery, obstetrics, paediatrics, epidemiology, sociology, psychology, economics, health administration, and mothers. Careful review of the knowledge of birth technology led to unanimous adoption of the recommendations which follow. WHO believes these recommendations to be relevant to perinatal services worldwide.

Every woman has the right to proper prenatal care and she has a central role in all aspects of this care, including participation in the planning, carrying out, and evaluation of the care. Social, emotional, and psychological factors are fundamental in understanding how to provide proper perinatal care. Birth is a natural and normal process, but even "no risk pregnancies" can give rise to complications. Sometimes intervention is required to obtain the best result. In order for the following recommendations to be viable, a thorough transformation of the structure of health services is required together with modification of staff attitudes and the redistribution of human and physical resources.

GENERAL RECOMMENDATIONS

Health ministries should establish specific policies regarding appropriate birth technology for the private and nationalised health services.

Countries should carry out joint surveys to evaluate birth care technologies.

The whole community should be informed of the various procedures in birth care, so as to enable each woman to choose the type of birth care she prefers.

The mother and her family should be encouraged to practise self-care in the perinatal period and develop the understanding of when and what help is required to improve the conditions of pregnancy, birth, and afterwards.

Women's mutual aid groups offer valuable social support and a unique opportunity to share information about birth.

The health team must foster coherent attitudes to ensure continuity in the monitoring of birth and the perinatal team should share a common work philosophy in order to ensure that staff changes do not jeopardise continuity of care.

Informal perinatal care systems (including traditional birth attendants) must coexist with the official system and a collaborative approach must be maintained for the benefit of the mother. Such relations, when established in parallel, can be highly effective.

Professional training should pass on new knowledge of the social, cultural, anthropological, and ethical aspects of birth.

The perinatal team should be jointly motivated to enhance relationships between mother, child, and family. The work of the team can be affected by interdisciplinary conflicts, which should be systematically explored.

The training of health professionals should include communication techniques in order to promote sensitive exchange of information between members of the health team and the pregnant woman and her family.

The training of professional midwives or birth attendants should be encouraged. Care during normal pregnancy, birth, and afterwards should be the duty of this profession.

Technology assessment should involve all those using the technology, epidemiologists, social scientists, health authorities, and the women on whom the technology is used.